Busseron Creek Watershed TMDL Development

REVISED PUBLIC REVIEW DRAFT

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Prepared for
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EXECUTIVE SUMMARY

The Busseron Creek watershed drains approximately 235 square miles of primarily agricultural, forested, and abandoned mining lands in southwestern Indiana. Several waterbodies in the watershed do not meet water quality standards and appear on Indiana's Clean Water Act Section 303(d) list of impaired waters. Federal law and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for such impaired waters. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. This report presents the TMDLs for the Busseron Creek watershed and provides recommendations for activities that are necessary to restore water quality in the watershed.

One of the first tasks of this project was to re-assess the causes of impairment appearing on the 2006 Section 303(d) list for the Busseron Creek watershed. Such re-assessments are frequently made at the beginning of TMDL projects to utilize any new information that might be available since the original listing decisions were made. As a result of the re-assessment, the pollutants for which TMDLs were developed differ from the pollutants appearing on the 2006 Section 303(d) list for the following reasons:

- Sampling performed by the Indiana Department of Environmental Management (IDEM) in 2006 generated new water quality data that were not available at the time the 2006 Section 303(d) list was developed.
- Indiana is in the process of modifying its criteria for sulfates. Although many of the waterbodies in the watershed did not meet the old criteria, they all meet the proposed criteria.
- Indiana's revised water quality standards no longer contain a numeric criterion for total dissolved solids. No TMDLs were therefore developed for the waterbodies previously listed for total dissolved solids.
- Sampling performed by the U.S. Geological Survey in September 2007 documented more widespread biological impairments in the Busseron Creek watershed than were previously known to exist. The most likely cause of the widespread biological impairments is concentrations of metals (primarily total iron and total aluminum) that do not meet IDEM's numeric criteria.

Once the TMDL pollutants had been identified, the various potential sources were evaluated. The primary source of the metals is believed to be runoff from historic (abandoned) and therefore unregulated mining activities. Sources of other pollutants, such as phosphorus and total suspended solids, include runoff from row crops, livestock operations, and failing septic systems.

Load duration curves were used to calculate observed and allowable pollutant loads for each of the impaired waterbodies and the allowable loads were allocated to regulated and unregulated sources, as required by the Clean Water Act. Relatively large reductions in observed loads are needed to meet water quality standards for most pollutants for most waterbodies in the watershed. Because the majority of loading is originating from unregulated sources, the voluntary adoption of various best management practices will be needed to achieve the recommended reductions. Such practices should include filter strips, nutrient management plans, conservation tillage, and septic system maintenance programs. Current efforts by the Indiana Department of Natural Resources to address runoff from historic mining areas are also critical and should receive a high priority for continued funding. Periodic monitoring of the watershed should be conducted to track progress toward meeting water quality standards, and to adjust implementation strategies to prioritize those activities found to be most cost effective.

1.0 INTRODUCTION

The Busseron Creek watershed drains approximately 235 square miles of primarily agricultural, forested, and abandoned mining lands in southwestern Indiana. A majority of the watershed is located in Sullivan County with smaller portions in Clay, Greene and Vigo counties (Figure 1). Tributaries to Busseron Creek include Sulpher Creek, Mud Creek, Big Branch, Kettle Creek, Buttermilk Creek and Robbins Creek. Indiana's 2006 Clean Water Act Section 303(d) list of impaired waters includes ten waterbody segments in the Busseron Creek watershed that were considered impaired due to total copper, total nickel, total zinc, sulfates, pH, impaired biotic communities, nutrients, low dissolved oxygen, and total dissolved solids (TDS). The listings and causes of impairment have been adjusted as a result of this study, due to new sampling results and a reassessment of the new data. The updated information is shown in Table 1 which compares the 2006 listings with the causes of impairments addressed by the TMDLs. (IDEM has re-segmented several waterbodies for the 2008 list and this information is summarized in Table 2.) Pollutants for which TMDLs are presented in this report are total aluminum, total copper, total iron, total manganese, total suspended solids, total phosphorus, dissolved oxygen, pH, and total zinc. All of the TMDLs are intended to address the impaired biotic communities that have been observed at various locations in the watershed.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) lists. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis.

The overall goals and objectives of the TMDL study for the Busseron Creek watershed were to:

- Further assess the water quality of the Busseron Creek watershed and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science to determine the maximum load of the pollutants of concern that the streams can receive and still fully support all of their designated uses.
- Use the best available science to determine current loads and sources of the pollutants of concern. If current loads exceed the maximum allowable load, determine the load reduction that is needed.
- Identify feasible and cost-effective actions that can be taken to reduce loads.
- Inform and involve the stakeholders throughout the project to ensure that key concerns are addressed and the best available information is used.
- Submit a final TMDL report to EPA for review and approval.

This project was implemented in the following phases:

1) The first phase involved the compilation and review of all the historical data and an identification of any data gaps necessary for the completion of TMDLs.
2) The second phase involved the collection of additional data to fill the identified gaps. IDEM collected additional water chemistry at 25 monitoring locations from August 22 through December 12, 2006 and the U.S. Geological Survey collected additional fish and water chemistry data from September 17 to 19, 2007.
3) The third phase involved the review and assessment of the collected data to make a final determination on the most likely causes of impairment. A number of factors were considered during this step, including a better understanding of the extent of the biological impairment in the watershed as well as the proposed change to Indiana's water quality standards for sulfate.

4) The final phase of the project was to calculate the allowable loads of the pollutants confirmed as causing impairments and to allocate those loads to the appropriate sources.

This report describes the entire analysis and, once finalized, will be submitted to EPA for approval as required by the Clean Water Act.

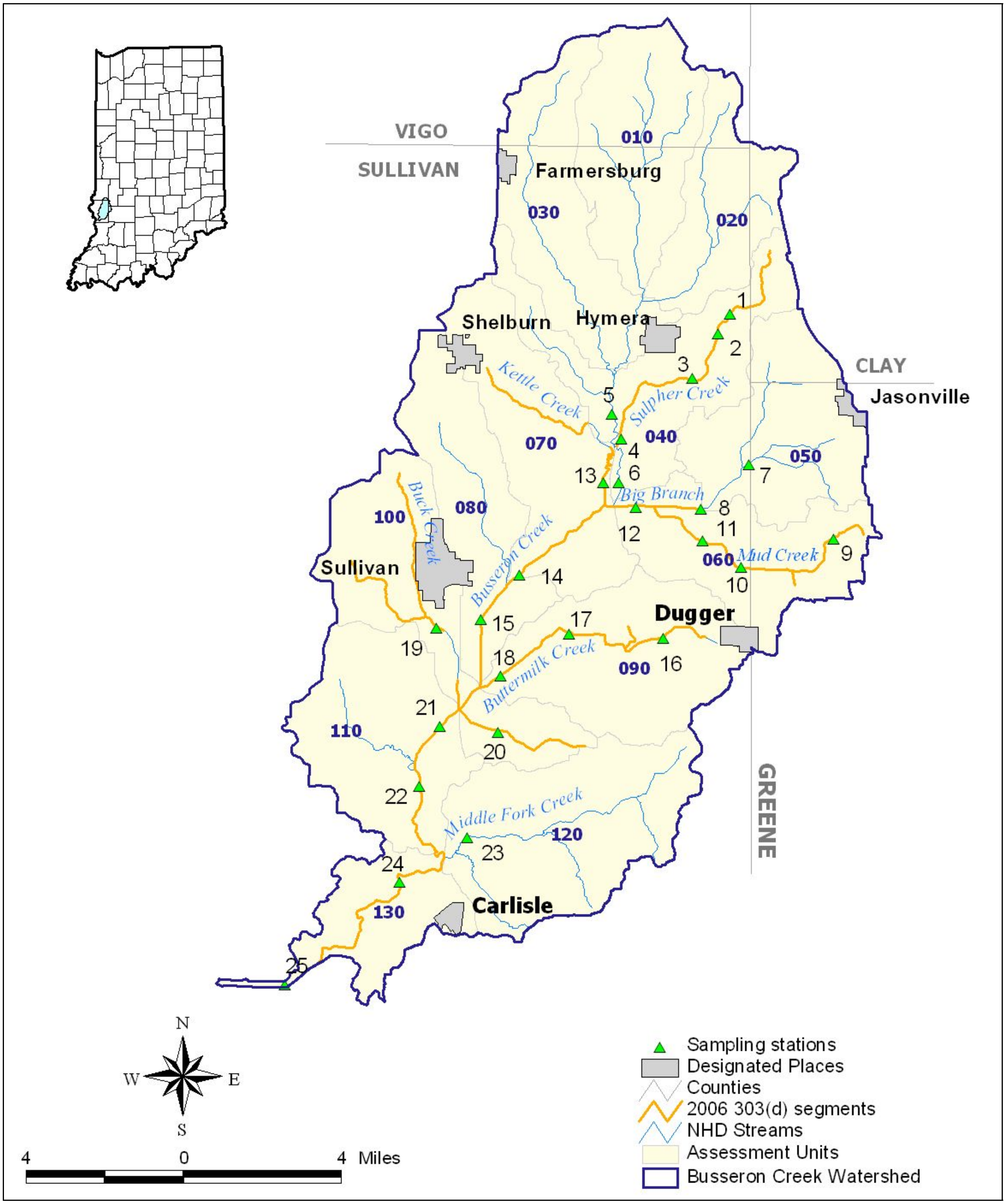

Figure 1. Location of the Busseron Creek Watershed and IDEM 2006 sampling stations.

Table 1. 2006 303(d) List Information for the Busseron Creek Watershed.

2006 Information	Updated Information for 2008

Waterbody	Segment ID	2006 Section 303 (d) Cause(s) of Impairment	Waterbody[1]	Updated Segment ID	2008 Updated Cause(s) of Impairment
Big Branch - Mud Creek	INB11G6_00	Sulfates	Mud Creek	INB11G6_03	Impaired Biotic Communities; Total Iron; Total Aluminum; Dissolved Oxygen[2]; pH[2]; Total Suspended Solids
				INB11G6_04	Impaired Biotic Communities; Total Iron; Total Aluminum; Total Suspended Solids
			Big Branch	INB11G6_02	Total Aluminum; Total Iron; Impaired Biotic Communities
Big Branch Tributary - Gilmour	INB11G5_00	Sulfates; Total Dissolved Solids	Big Branch	INB11G5_02	Total Aluminum; Impaired Biotic Communities
Busseron Creek	INB11G8_T1036	Sulfates; Total Dissolved Solids	Busseron Creek	INB11G8_T1036	Impaired Biotic Communities; Dissolved Oxygen
Sulpher Creek	INB11G4_T1024	Total Copper, Total Nickel, Total Zinc, Sulfates, pH, Biotic Communities, Low Dissolved Oxygen, Total Dissolved Solids	Sulpher Creek	INB11G4_T1004	Total Aluminum; Total Copper; Impaired Biotic Communities; Total Iron; pH; Total Phosphorus; Total Manganese; Total Suspended Solids; Total Zinc
				INB11G4_T1005	Total Aluminum; Total Iron; Impaired Biotic Communities; pH; Total Phosphorus; Total Manganese; Total Copper; Total Suspended Solids; Total Zinc
				INB11G4_T1006	Total Aluminum
Busseron Creek - Hymera	INB11G7_T1035	Sulfates; Total Dissolved Solids	Busseron Creek	INB11G7_02	Total Phosphorus; Dissolved Oxygen; Impaired Biotic Communities; Total Suspended Solids
Kettle Creek	INB11G7_00	Dissolved Oxygen	Kettle Creek	INB11G7_01	None
Busseron Creek - Paxton	INB11GB_T1037	Sulfates; Total Dissolved Solids	Busseron Creek	INB11GB_01	Impaired Biotic Communities

				INB11GB_02	Impaired Biotic Communities
Busseron Creek - Tanyard Branch	INB11GD_00	Sulfates; Total Dissolved Solids	Busseron Creek	INB11GD_01	None
				INB11GD_02	
Buttermilk Creek	INB11G9_00	Sulfates; Total Dissolved Solids	Buttermilk Creek	INB11G9_01	Total Aluminum; Impaired Biotic Communities; Total Suspended Solids
				INB11G9_03	Total Aluminum; Impaired Biotic Communities; Total Suspended Solids; Total Iron
Robbins Creek	INB11GA_00	Nutrients	Robbins Creek	INB11GA_02	Impaired Biotic Communities; Total Phosphorus; Dissolved Oxygen[2]
			Buck Creek	INB11GA_03	Impaired Biotic Communities; Total Phosphorus; TSS; Dissolved Oxygen[2]

[1]Busseron Creek segment INB11G4_01 appeared in this table during the first public review period (January 23, 2008 to March 5, 2008) but was subsequently removed based on a reassessment of the data.
[2]Impairment based on data collected by USGS or IDNR in accordance with the IDEM Standard Operating Procedure (see Appendix A for additional information).

Recently IDEM began using the high resolution National Hydrography Dataset (NHD) created by USGS. Previously IDEM could only view streams at medium resolution (1:100,000 scale). The high resolution streams are at the 1:24,000 scale, which allows for a more detailed view of the watershed. These high resolution waters have always been present; however, they have not been visible in electronic maps until now. A reassessment was completed with regard to the high resolution streams in the Busseron Creek watershed. Since many more streams are visible at high resolution, Table 2 lists the high resolution streams that will be included in the analysis at each station and with the associated medium resolution segment ID.

Table 2. Updated High Resolution Segments will be addressed in the document under the following Segment and Station IDs.

Waterbody	Station	Updated Segment ID	TMDL Developed	Impairment Addressed	High Resolution Segment ID	14-Digit HUC
Sulphur Creek	Station 2	INB11G4_T1005	Total Aluminum; Total Iron; Total Phosphorus; pH; Total Zinc; TSS	Total Aluminum; Total Iron; Impaired Biotic Communities; pH; Total Phosphorus; Total Manganese; Total Copper; Total Suspended Solids; Total Zinc	INB11G4_T1005A	5120111160040
	Station 3	INB11G4_T1005	Total Aluminum; Total Copper; Total Iron; Total Manganese; Total Phosphorus; Total Zinc	Total Aluminum; Total Iron; Impaired Biotic Communities; pH; Total Phosphorus; Total Manganese; Total Copper; Total Suspended Solids; Total Zinc	INB11G4_T1005B	
	Station 4	INB11G4_T1006	Total Aluminum	Total Aluminum	INB11G4_T1005C	
					INB11G4_T1005D	
					INB11G4_T1005D1	
					INB11G4_T1005E	
					INB11G4_T1005E1	
					INB11G4_T1005F	
					INB11G4_T1005G	
					INB11G4_T1005G1	
					INB11G4_T1006A	
					INB11G4_T1006B	
Mud Creek	Station 9	INB11G6_03	Total Aluminum; Total Iron; pH	Impaired Biotic Communities, Total Iron, Total Aluminum, Dissolved Oxygen, pH, Total Suspended Solids	INB11G6_03A	5120111160060
					INB11G6_03B	
					INB11G6_03B1	
					INB11G6_03B2	
					INB11G6_03C	
					INB11G6_03D	
					INB11G6_03E	
					INB11G6_T1001	
					INB11G6_T1002	
					INB11G6_T1002A	
					INB11G6_T1002B	
	Station 10	INB11G6_04	Total Aluminum; Total Iron; Total Suspended	Impaired Biotic Communities; Total Iron; Total	INB11G6_T1003	
					INB11G6_T1003A	
					INB11G6_T1003B	

			Solids; Dissolved Oxygen	Aluminum; Total Suspended Solids	INB11G6_T1003C INB11G6_04A INB11G6_04B INB11G6_04C	
	Station 11	INB11G6_04	Total Aluminum; Total Iron	Impaired Biotic Communities; Total Iron; Total Aluminum; Total Suspended Solids	INB11G6_04D INB11G6_04G INB11G6_04H INB11G6_04I INB11G6_T1004	
Big Branch	Station 12	INB11G6_02	Total Aluminum; Total Iron	Total Aluminum; Total Iron; Impaired Biotic Communities	INB11G6_T1005 INB11G6_T1005A INB11G5_T1002 INB11G5_T1002A INB11G5_T1002B INB11G5_T1002B1 INB11G5_T1002B2	5120111160050
Buttermilk Creek	Station 16 and Station 17	INB11G9_01	Total Aluminum; Total Iron; Total Suspended Solids	Total Aluminum; Impaired Biotic Communities; Total Suspended Solids	INB11G9_01A INB11G9_01B INB11G9_01C INB11G9_01D INB11G9_01E INB11G9_01F INB11G9_01G INB11G9_01H INB11G9_01I INB11G9_01J INB11G9_01K INB11G9_02A INB11G9_02A1 INB11G9_02A1A	5120111160090
Buck Creek	Station 19	INB11GA_03	Total Phosphorus, Dissolved Oxygen, Total Suspended Solids	Impaired Biotic Communities; Total Phosphorus; TSS; Dissolved Oxygen	INB11GA_03A INB11GA_03B INB11GA_03C INB11GA_03D INB11GA_03E INB11GA_03E1 INB11GA_03E2 INB11GA_03F INB11GA_03G INB11GA_03H INB11GA_04A INB11GA_04B INB11GA_04C INB11GA_04D INB11GA_04E INB11GA_04F	5120111160100

					INB11GA_04G	
					INB11GA_04H	
					INB11GA_04I	
					INB11GA_04J	
Robbins Branch	Station 20	INB11GA_02	Total Phosphorus	Impaired Biotic Communities; Total Phosphorus; Dissolved Oxygen	INB11GA_02A	
					INB11GA_02A1	
					INB11GA_02B	
					INB11GA_02C	
					INB11GA_02D	
					INB11GA_02E	
					INB11GA_02F	
					INB11GA_02G	

2.0 DESCRIPTION OF THE WATERSHED

The Busseron Creek watershed lies within the greater Lower Wabash watershed and flows to the southwest for about 30 miles before discharging into the Wabash River west of Carlisle. A large part of the watershed lies in Sullivan County which covers approximately 82 percent of the watershed (Figure 1). The remaining portions of the watershed lie in Greene (7.75%), Vigo (6.65%), and Clay (3.48%) counties. Incorporated cities within the watershed include Farmersburg, Shelburn, Sullivan, Hymera, Dugger, and Carlisle in Sullivan County and Jasonville in Greene County.

The following sections of this report provide information on the population, land uses, topography, and hydrology of the watershed.

2.1 Population

The population of the Busseron Creek watershed is not directly available but was estimated at approximately 15,400 based on U.S. Census (2000) data and the size of the watershed (Table 3). The City of Sullivan, with a population of 4,617, is the largest community in the watershed.

Table 3. Population data for counties within the Busseron Creek Watershed

County	Total Estimated Watershed Population	Percent of Total Watershed Population	Non-urban Population	Urban Population
Clay	611	3.80	611	0
Greene	1347	8.36	491	856
Sullivan	9456	58.82	1478	7978
Vigo	4000	29.01	4000	0
Total	15414	100	6580	8834

Source: U.S. 2000 Census and geographic information system (GIS) analysis.

2.2 Topography and Soils

The Busseron Creek watershed is located in the Wabash Lowland physiographic region which is characterized by a broad lowland tract having an average elevation of 500 feet. The watershed is underlain by siltstone and shale of Pennsylvanian age and is comprised of extensive aggraded valleys and pockets of thick lacustrine, outwash, and alluvial sediments (USGS, 1983). Most soils in the watershed are classified as poorly draining C and D soils (61% and 6%, respectively), followed by moderately draining B soils (33%). Figure 2 shows the general topography within the watershed and indicates that elevations range from 415 to 677 feet with an average slope throughout the watershed of 5.4 ft per mile.

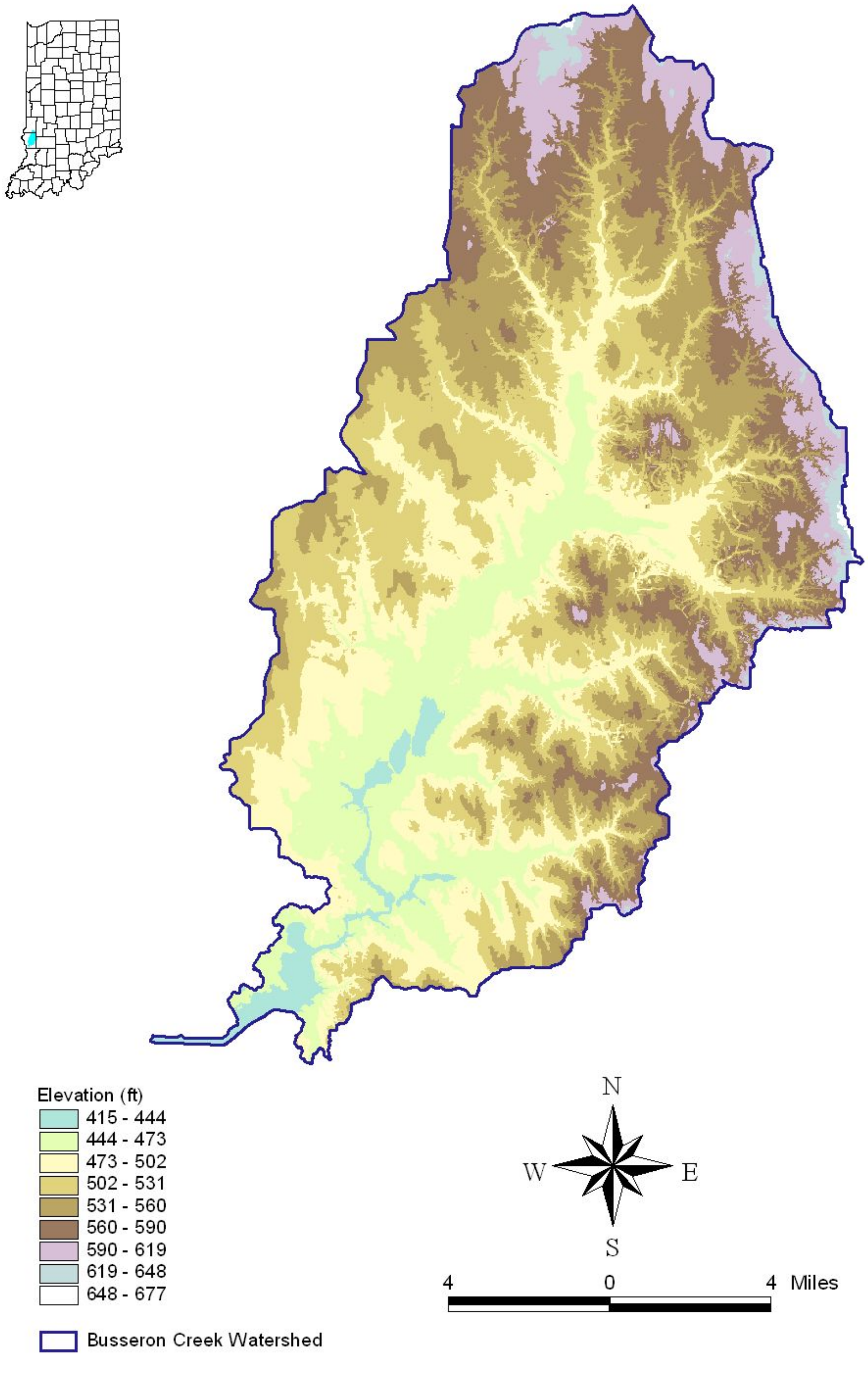

Figure 2. Topography in the Busseron Creek Watershed.

2.3 Land Use/Land Cover

Land use information for the Busseron Creek watershed is available from the Multi-Resolution Land Characteristics Consortium (MRLC). These data categorize the land use for each 30 meters by 30 meters parcel of land in the watershed based on satellite imagery from circa 2000. Figure 3 displays the spatial distribution of the land uses and the data are summarized in Table 4. A majority of the land (65 percent) is classified as agricultural with another 20 percent of the watershed comprised of forest land.

Figure 4 shows the location of known abandoned mine lands in the watershed. A comparison of Figure 3 and Figure 4 indicates that many of the abandoned surface mining sites are classified as forest in the land use/land cover database (some of the abandoned sites are classified as other land uses/land cover as noted by the total percentage of land area being greater than 100). The data used to create Figure 3 indicate that there are approximately 34 square miles of abandoned surface mine sites and 48 square miles of underground mines in the watershed.

Table 4. Land Use and Land Cover in Busseron Creek Watershed.

Land Use/Land Cover	Watershed		
	Area		Percent
	Acres	Square Miles	
Urban Areas	3,749	5.86	2.50%
Forest	36,510	57.05	24.10%
Agriculture	97,791	152.8	64.60%
Water/Wetlands	11,867	18.54	7.80%
Grasslands	1,419	2.22	0.90%
Surface Mines		34	14.38%
Underground Mines		48	20.30%
Total	151,336	236.47	134.58%

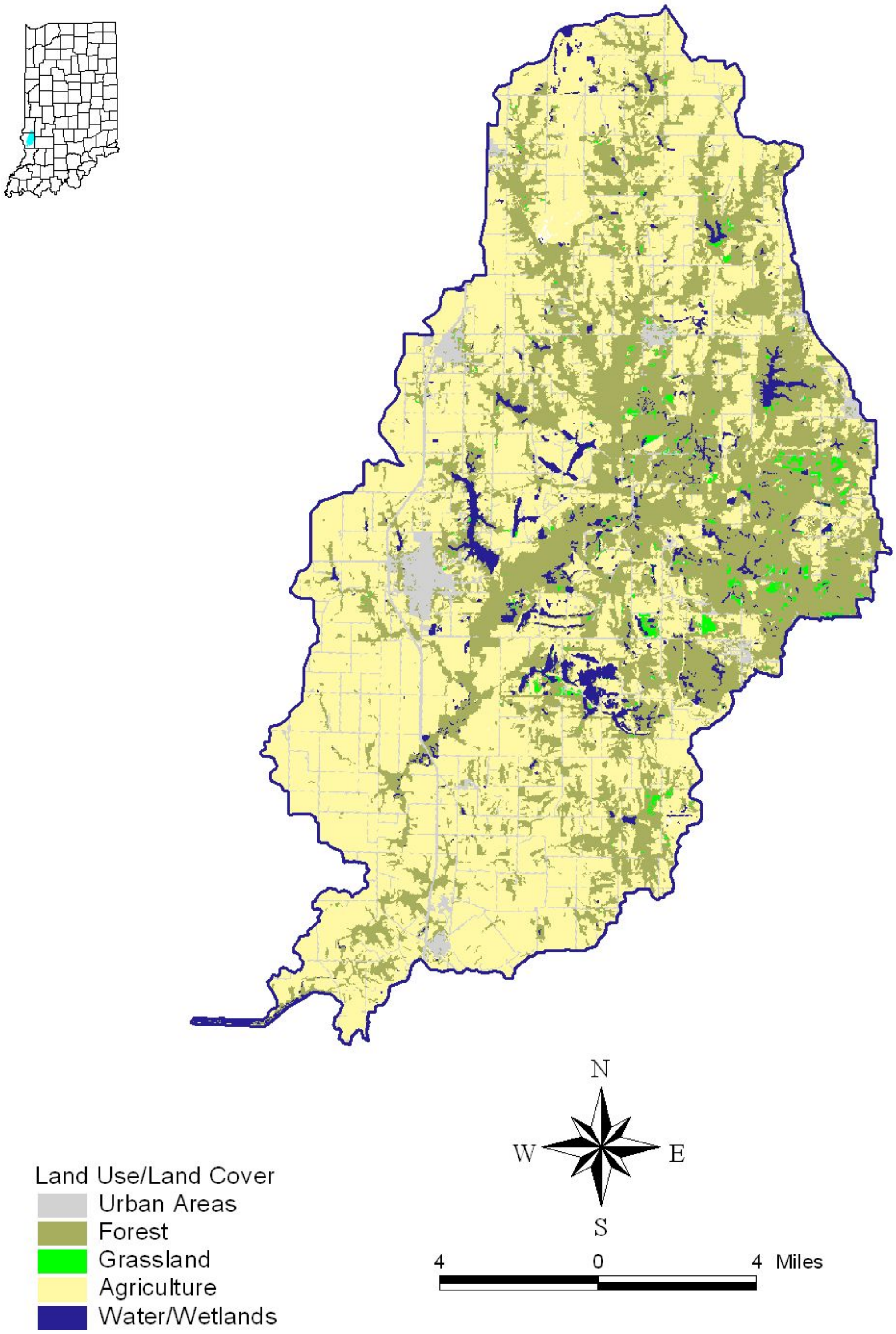

Figure 3. Land Use in the Busseron Creek Watershed.

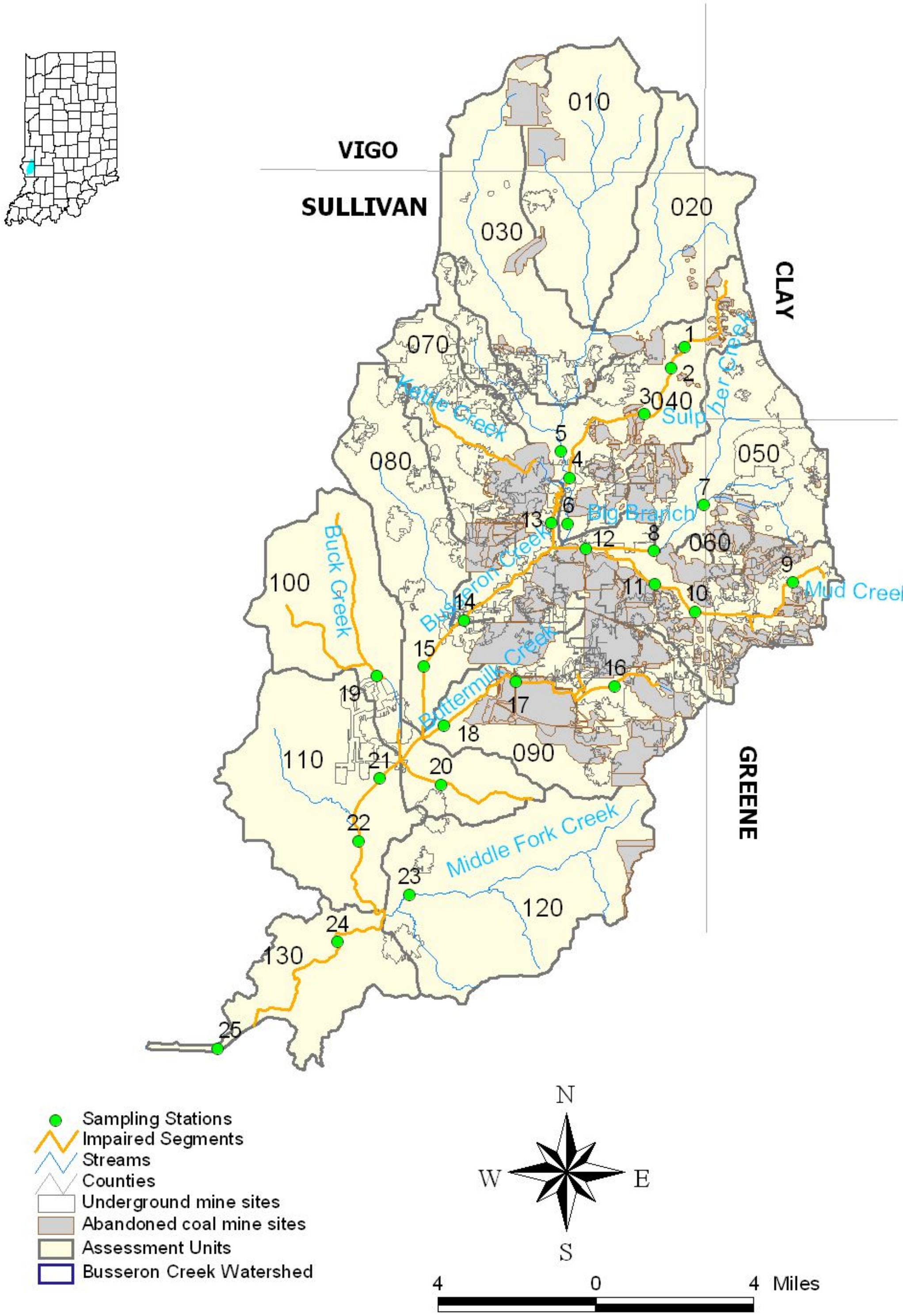

Figure 4. Abandoned mine lands in the Busseron Creek watershed.

2.4 Hydrology

There is one active flow gaging station (U.S. Geological Survey (USGS) gage ID 03342500) on Busseron Creek located near Carlisle. The average daily flows for this gage from the period 1970 to 2007 are shown in Figure 5 and indicate that flows are typically the greatest during winter and spring (December through April) and least during late summer and fall (August through October).

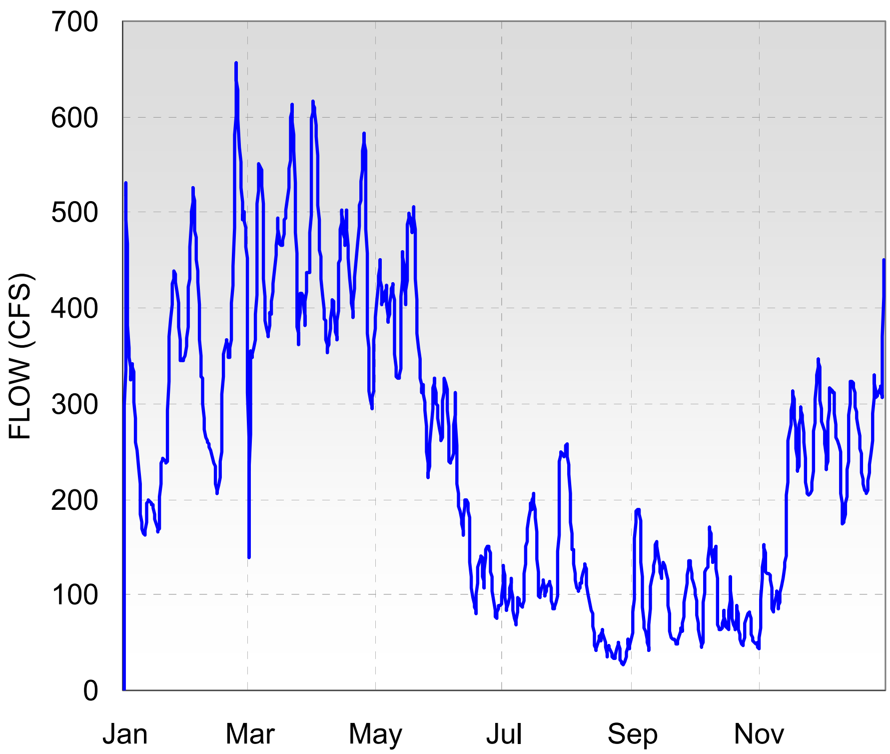

Figure 5. Average Daily Flow at Busseron Creek near Carlisle, IN, USGS Station 03342500 (1970 to 2007; note that no flows recorded for period December 2, 2003 to May 2, 2007).

3.0 INVENTORY AND ASSESSMENTOF WATER QUALITY INFORMATION

This section of the report provides information on the water quality standards that apply to the impaired streams in the Busseron Creek watershed and provides a summary of existing water quality.

3.1 Water Quality Standards and TMDL Target Values

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of several different components:

- **Designated uses** reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and full body contact recreation. Every waterbody in Indiana has a designated use or uses; however, not all uses apply to all waters. All surface waters in the Busseron Creek watershed have been designated to support a well-balanced, warm water aquatic community.
- Criteria express the condition of the water that is necessary to support the designated uses. **Numeric criteria** represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. **Narrative criteria** are the general water quality criteria that apply to all surface waters. The relevant narrative criteria that apply to the TMDLs presented in this report state the following:

> *"All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:" [327 IAC 2-1-6. Sec. 6. (a)(1)]…*
>
> *(a)re in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses." [327 IAC 2-1-6. Sec. 6. (a) (1)(D)]*
>
> *(a)re in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans." [327 IAC 2-1-6. Sec. 6. (a) (1)(E)]*

3.2 Target Values

Target values are needed for the development of TMDLs because of the need to calculate allowable daily loads. For parameters that have numeric criteria, the numeric criteria are used as the TMDL target value. For example, numeric criteria (that vary by hardness) exist for copper and zinc and equations that specify the criteria can be found in the Indiana Administrative Code at 2-1-6 Table 6-2.

For parameters covered only by narrative criteria, target values must be identified from some other source. For example, Indiana has adopted a 0.30 mg/L target for total phosphorus to quantify the narrative criteria that requires that waters shall be from substances that "contribute to the growth of nuisance aquatic plants or algae”. Additional information on the total phosphorus target value and how it was derived are presented in Appendix H.

Aluminum and Iron aquatic life criteria for Indiana’s non-Great Lakes Basin waters have not been promulgated into Indiana’s water quality standards (327 IAC, Article 2). However, provisions found at 327 IAC 2-1-8.2 and 2-1-8.3 clarify the procedures for determining aquatic life criteria for non-Great Lakes Basin waters in Indiana. Additionally, provisions at 327 IAC 2-1-13 allow for site-specific modifications to criteria as long as the modified criteria are protective of designated uses and aquatic life or human health. In March 2005, site-specific Aluminum criteria for Indiana warm waters were calculated by IDEM utilizing procedures in the rules cited above. The national Water Quality Criteria (WQC) for Aluminum were based on acute toxicity data from 14 Genera, including cold water species. However, Aluminum water quality criteria (WQC) for Indiana warm waters were derived by eliminating toxicity data for the cold water species that are not representative of warm waters while taking into consideration acceptable data that were available at the time of criteria derivation. Therefore, the resulting acute and chronic criteria of 993 µg/L and 174 µg/L, respectively, are less restrictive than EPA’s national acute and chronic criteria of 748 µg/L and 87 µg/L, respectively.

In June 1997, IDEM calculated WQC for Iron according to the provisions in Indiana Rule 327 IAC 2-1-8.2 and 2-1-8.3. The available acute toxicity data satisfied Indiana’s 5 families’ data requirements for resident species. Therefore, utilizing the procedures described in the above mentioned provisions, the acute and chronic WQC for non Great Lakes Basin waters were determined to be 2744 µg/L and 2495 µg/L, respectively.

To understand the water quality criteria for aluminum, copper, iron, manganese, and zinc a number of factors must be considered:

1) *Dissolved versus Total:* Indiana has adopted both dissolved and total recoverable criteria for aluminum, copper, iron, manganese, and zinc. Both types of criteria were used to evaluate impairment conditions within the watershed; however, loading capacities were based upon the total recoverable criteria because significantly more total recoverable data are available with which to assess current loads (and thus necessary reductions).
2) *Acute versus Chronic:* Indiana has also adopted both Acute Aquatic Criteria (AAC) and Chronic Aquatic Criteria (CAC) for aluminum, copper, iron, manganese, and zinc. Acute toxicity means a substance has been introduced that is severe enough to rapidly induce a response (e.g., within 96 hours or less). Chronic toxicity refers to the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity. There were enough aluminum, copper, iron, manganese, and zinc data to calculate the loading capacities in the Busseron Creek watershed using the chronic criteria. Chronic criteria are more restrictive and ensure that both standards will be met. Chronic criteria also provide a more valid comparison to the available observed data (e.g., multiple samples within a 96 hour period to compare to the acute criteria are not available at any location in the watershed).
3) *Hardness.* The criteria for copper, manganese, and zinc vary according to the hardness of the water because the harder the receiving water, the less toxic the metals will be. Appendix C displays the hardness for each sampling event and the corresponding criteria are presented in Appendix D. The lowest of these criteria from among all samples that exceeded both the acute and chronic criteria were used to calculate the loading capacities.

Table 5 summarizes the target values used for the Busseron Creek watershed TMDLs along with an explanation of how they were derived. All of these target values are intended to improve water quality so that a well-balanced, warm water aquatic community exists in the waterbody. The target values for pH, total iron, total aluminum, total copper, total zinc, and total manganese are intended to reduce the toxicity caused by these pollutants at elevated levels. The targets are based on toxicity information and are developed to protect aquatic organisms from death, slower growth, reduced reproduction, and the accumulation of harmful levels of toxic chemicals in their tissues that may adversely affect consumers of such organisms.

It should be noted that no loads of pH were calculated; instead, the metals TMDLs are expected to result in attainment of the pH targets. This is due to the fact that, in watersheds such as Busseron Creek that are impacted by historic mine lands that have been abandoned, low pH is generally caused by water with elevated concentrations of metals becoming acidic after oxidation and precipitation of the metals. Therefore, meeting the targets for metals concentrations should also result in meeting the pH targets.

The target value for total phosphorus is intended to limit the negative effects on aquatic ecosystems that can occur due to increasing algal and aquatic plant life production associated with higher nutrient concentrations (Sharpley et al., 1994). Increased plant production increases turbidity, decreases average dissolved oxygen concentrations, and increases fluctuations in diurnal dissolved oxygen and pH levels. Such changes shift aquatic species composition away from functional assemblages comprised of intolerant species, benthic insectivores, and top carnivores that are typical of high quality streams towards less desirable assemblages of tolerant species, generalists, omnivores, and detrivores that are typical of degraded streams (OEPA, 1999). Such a shift in community structure lowers the diversity of the system.

The target value for total suspended solids (TSS) is based on the fact that TSS can reduce the amount of sunlight available to aquatic organisms and decrease water clarity. This leads to a number of effects including: reduction of aquatic plants available for consumption by higher level organisms, lower dissolved oxygen, and the impaired ability of fish to see and catch food. TSS particles can also hold heat resulting in increased stream temperature. Further, TSS can clog fish gills, retard growth rates, decrease resistance to disease, and prevent egg and larval development. When TSS settles on the bottom of a waterbody, eggs of fish and invertebrates are smothered, larvae can suffocate, and habitat quality is degraded (OEPA, 1999).

It should be noted that loads of dissolved oxygen were not calculated but instead the total phosphorus and TSS TMDLs are expected to result in attainment of the dissolved oxygen water quality standard. This is due to the interrelationship between these pollutants and dissolved oxygen as explained in the two preceding paragraphs.

Table 5. Target values used for development of the Busseron Creek watershed TMDLs.

Parameter	Target Value	Source
Total phosphorus	No value should exceed 0.30 mg/L	This is a target used by IDEM to interpret the narrative nutrient criteria (327 IAC 2-1-6).
pH	No pH values should be below six (6.0) or above nine (9.0), except daily fluctuations that exceed pH nine (9.0) and are correlated with photosynthetic activity, shall be permitted.	Numeric Criteria (327 IAC 2-1-6)
Dissolved Oxygen	Concentrations of dissolved oxygen shall average at least five (5.0) milligrams per liter per calendar day and shall not be less than four (4.0) milligrams per liter at any time.	Numeric Criteria (327 IAC 2-1-6)
Total Iron	No value should exceed 2.5 mg/L	This numeric criterion was developed by IDEM following the process explained in 327 IAC 2-1-8; see Appendix H for details
Total Aluminum	No value should exceed 174 µg/L	This numeric criterion was developed by IDEM following the process explained in 327 IAC 2-1-8; see Appendix H for details
Total Suspended Solids	No value should exceed 30 mg/L	This is a target used by IDEM to interpret the narrative sediment criteria (327 IAC 2-1-6).
Total Copper	AAC (µg/L) = WER ($e^{(0.9422[\ln(\text{hardness})]-1.464)}$) Conversion factor = 0.96[a] CAC (µg/L) = WER ($e^{(0.8545[\ln(\text{hardness})]-1.465)}$) Conversion factor = 0.96 [a]	Numeric Standard (327 IAC 2-1-6). Table 6-2.
Total Zinc	AAC (µg/L) = WER ($e^{(0.8473[\ln(\text{hardness})]+0.8604)}$) Conversion factor = 0.978 [a] CAC (µg/L) = WER ($e^{(0.8473[\ln(\text{hardness})]+0.7614)}$) Conversion factor = 0.986 [a]	Numeric Standard (327 IAC 2-1-6). Table 6-2.
Total Manganese	AAC (µg/L) = ($e^{(0.8784[\ln(\text{hardness})]+2.992)}$) CAC (µg/L) = ($e^{(0.8784[\ln(\text{hardness})]+2.226)}$) Conversion factor = 1 [a]	These numeric criteria were developed by IDEM following the process explained in 327 IAC 2-1-8; see Appendix H for details.

Notes: AAC = Acute Aquatic Criterion; CAC = Chronic Aquatic Criterion.
[a] Dissolved criteria for each of these parameters are computed by multiplying the AAC and CAC by the corresponding conversion factor.

3.3 Assessment of Water Quality

This section provides a summary of the water quality of the Busseron Creek watershed.

3.3.1 Biological Data

Sampling performed by USGS in September 2007 documented widespread biological impairments in the Busseron Creek watershed as summarized in Table 6. Several potential reasons for the widespread impairments were identified through the TMDL effort including:

- The oxidation of iron may be consuming large amounts oxygen which in turn stresses fish and other aquatic organisms.
- TSS can reduce plants available for consumption, lower dissolved oxygen levels, impair the ability of fish to see and catch food, increase stream temperature, clog fish gills, slow growth rates, decrease disease resistance, and prevent the development of eggs and larvae.
- Total phosphorus can cause increased plant production resulting in increased turbidity, decrease dissolved oxygen levels, and cause greater fluctuations in diurnal dissolved oxygen and pH levels resulting in lower stream diversity.

- Various metals, especially iron and aluminum, may be present at high enough concentrations as to be toxic to aquatic life.

Attaining the targets shown in Table 5 will address these potential causes of impairment.

Table 6. Impaired Biotic Community Stream Segments in the Busseron Creek Watershed Identified During September 2007 USGS Sampling.

Stream	Score	Sampling Site	IBI Integrity Class
Sulfur Creek	12	2	Very Poor
Busseron Creek	20	5	Very Poor
Busseron Creek	42	6	Fair
Big Branch	28	7	Poor
Big Branch	14	8	Very Poor
Mud Creek	12	9	Very Poor
Mud Creek	16	11	Very Poor
Big Branch	18	12	Very Poor
Busseron Creek	24	14	Very Poor
Busseron Creek	22	15	Very Poor
Buttermilk Creek	28	16	Poor
Buttermilk Creek	36	18	Poor
Buck Creek	16	19	Very Poor
Robbins Branch	36	20	Poor
Busseron Creek	22	22	Very Poor
Busseron Creek	46	25	Fair

Notes: IBI = Index of Biotic Integrity. Scores calculated using IDEM's *Summary of Protocols: Probability Based Site Assessment*. (IDEM, 2005).

3.3.2 Chemistry Data

Table 7 summarizes the water chemistry data within the Busseron Creek watershed by displaying the maximum concentrations at all impaired stations along with the reduction needed to meet the TMDL target values. The percent reductions were calculated as follows:

$$\%\,\text{Reduction} = \frac{(\text{Target Value} - \text{Maximum})}{\text{Maximum}}$$

The table indicates the following:

- Reductions of 73 percent or greater are needed to meet the TMDL target values for total aluminum, total copper, total iron, TSS, and total zinc in Sulpher Creek.
- Reductions of 42 percent to 96 percent are needed to meet the TMDL target values for total aluminum and total iron in Mud Creek.
- Reductions varying from 40 to 82 percent are needed to meet the TMDL target value for total phosphorus in Sulpher, Kettle, and Robbins Creeks.

- Only one segment of Busseron Creek, INB11G4_00 located south of Hymera, is impaired (due to total aluminum and total iron).

Appendix B shows the individual sample results and statistical summaries of all the water quality data for all 25 monitoring stations.

Table 7. Summary of water chemistry data within the Busseron Creek watershed.

Stream Name	Station	Total Aluminum		Total Copper		Total Iron		Total Manganese		Total Phosphorus		TSS		Total Zinc	
		Maximum (μg/L)	Reduction	Maximum (μg/L)	Reduction	Maximum (μg/L)	Reduction	Maximum (μg/L)	Reduction	Maximum (mg/L)	Reduction	Maximum (μg/L)	Reduction	Maximum (μg/L)	Reduction
Sulpher Creek	1	14600	99%	No TMDL		32400	92%	No TMDL		0.5	40%	No TMDL		1430	83%
	2	13500	99%	No TMDL		35900	93%	No TMDL		1.16	74%	150	80%	1070	83%
	3	19700	99%	43.4	73%	23600	89%	1560	67%	1.04	71%	No TMDL		632	83%
	4	1800	90%	No TMDL		No TMDL		No TMDL		No TMDL		No TMDL		No TMDL	
Busseron Creek	5	4010	96%	No TMDL		3310	24%	No TMDL		No TMDL		No TMDL		No TMDL	
Mud Creek	9	4790	96%	No TMDL		4370	42%	No TMDL		No TMDL		No TMDL		No TMDL	
	10	36800	100%	No TMDL		69800	96%	No TMDL		No TMDL		61	50%	No TMDL	
	11	10300	98%	No TMDL		29300	91%	No TMDL		No TMDL		No TMDL		No TMDL	
Big Branch	12	868	80%	No TMDL		5500	54%	No TMDL		No TMDL		No TMDL		No TMDL	
Kettle Creek	13	No TMDL		No TMDL		No TMDL		No TMDL		1.76	82%	296	89%	No TMDL	
Buttermilk Creek	16	1020	83%	No TMDL		No TMDL		No TMDL		No TMDL		60	50%	No TMDL	
	17	2680	94%	No TMDL		11800	78%	No TMDL		No TMDL		41	26%	No TMDL	
Robbins Creek	19	No TMDL		No TMDL		No TMDL		No TMDL		0.6	50%	114	73%	No TMDL	
	20	No TMDL		No TMDL		No TMDL		No TMDL		0.5	40%	No TMDL		No TMDL	

Notes: "No TMDL" indicates that the stream at that station is not considered impaired for that pollutant and thus no TMDL is presented in this report.

3.3.3 Sulfates and Total Dissolved Solids Listings

As shown in Table 1 several waterbody segments within the Busseron Creek watershed were listed as impaired due to sulfates and total dissolved solids on the 2006 Section 303(d) list. No TMDLs were developed for these parameters because of the following:

- Sulfates – IDEM is in the process of modifying its sulfate criteria and the data have been re-assessed using the proposed criteria; the re-assessment indicates that none of the waterbodies within the Busseron Creek watershed are considered impaired for sulfates.

- Total Dissolved Solids – Indiana's revised water quality standards no longer contains a numeric criterion for this parameter. No target value has been identified to quantify the applicable narrative criteria and total dissolved solids are not considered to be a cause of the biological impairments.

4.0 SOURCE ASSESSMENT

This section summarizes the available information on significant sources of the pollutants of concern in the Busseron Creek watershed.

4.1 Permitted Point Sources

The term point source refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a waterbody. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term “point source” also includes: concentrated animal feeding operations (which are places where animals are confined and fed); storm water runoff from Municipal Separate Storm Sewer Systems (MS4s); and illicitly connected “straight pipe” discharges of household waste. Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

4.1.1 Wastewater Treatment Plants (WWTPs) and Industrial Facilities

Facilities with NPDES permits to discharge wastewater within the Busseron Creek watershed include municipal WWTPs and industrial facilities. There are 15 active NPDES permitted facilities within the Busseron Creek watershed (Figure 6 and Table 8). The seven municipal WWTPs in the watershed are potential sources of nutrients and TSS and the five industrial dischargers associated with active mining activities are potential sources of TSS, pH, and metals. Table 9 summarizes permit violations for several of the facilities in the watershed and indicates that multiple facilities have had recurring violations for one or more pollutants.

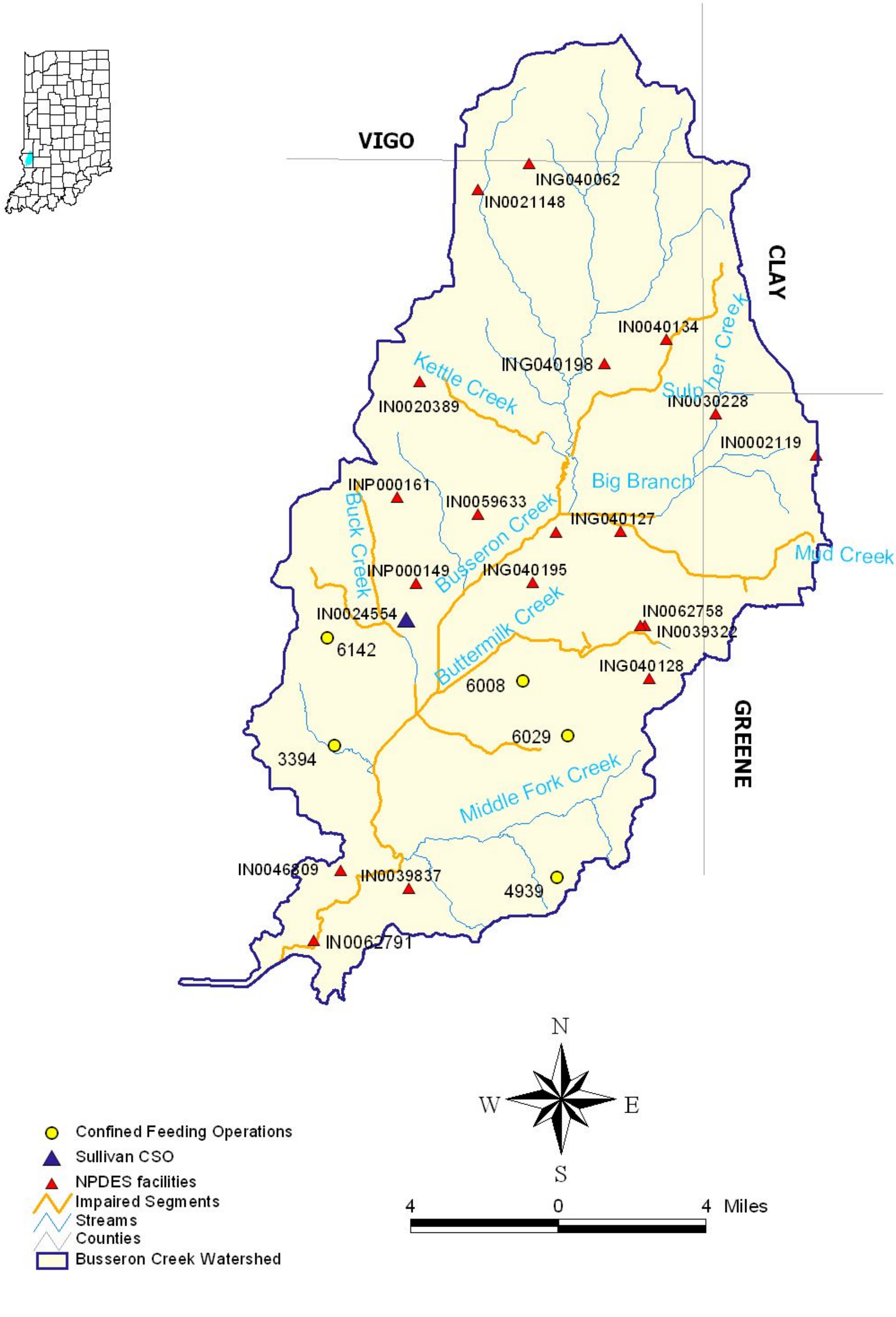

Figure 6. Location of NPDES facilities and confined feeding operations in the Busseron Creek Watershed.

Table 8. NPDES Permitted Wastewater Dischargers within the Busseron Creek Watershed

Facility	Permit Number	Receiving Stream
Shakamak State Park WWTP	IN0030228	Big Branch Creek
Hymera Municipal WWTP	IN0040134	Sulpher Creek
Sullivan Municipal WWTP	IN0024554	Busseron Creek via Buck Creek
Shelburn WWTP	IN0020389	Unnamed Tributary to Kettle Creek
Dugger WWTP	IN0039322	Buttermilk Creek
Carlisle WWTP	IN0039837	Busseron Creek
Town of Carlisle Water Department	IN0046809	Unnamed Ditch to Busseron Creek
Latta Indiana Diesel House	IN0002119	Busseron Creek via Big Branch
Glendora Test Facility	IN0059633	Unnamed ditch to Busseron Creek
Farmersburg WWTP	IN0021148	Busseron Creek (W FK) to Wabash River
Black Beauty Coal Farmersburg	ING040062	Busseron, Spunge and Turman Creeks
Farmersburg Mine Bear Run	ING040127	Kettle, Mud, Busseron, and Buttermilk Creeks
Coal Field Development, Hymera Mine	ING040198	Located in Sulpher Creek Subwatershed
Sunrise Coal	IN0062791	Busseron Creek
Jericho, Sullivan County CBM Field	IN0062758	Buttermilk Creek, Busseron Creek

Table 9. Summary of Permit Violations for the NPDES Facilities in the Busseron Creek Watershed for the Five Year Period Ending October 2007.

Facility	Violations from October 2002 through October 2007
Dugger WWTP	19 dissolved oxygen violations; 11 TSS violations
Farmersburg Mine Bear Run	14 pH violations; and 3 TSS violations (multiple outfalls)
Farmersburg Mine Bear Run (East Pit)	6 iron violations (multiple outfalls)
Farmersburg WWTP	10 dissolved oxygen violations; 1 pH violation; 87 TSS violations
Hymera Municipal WWTP	9 dissolved oxygen violations; 2 pH violations; 55 TSS violations
Shakamak State Park WWTP	8 dissolved oxygen violations; 1 pH violation; 15 TSS violations
Shelburn WWTP	2 dissolved oxygen violations; 3 total phosphorus violations; 14 TSS violations
Sullivan Municipal WWTP	6 pH violations; 1 TSS violation

4.1.2 Concentrated Animal Feeding Operations

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of concentrated animal feeding operations falls under the regulations for concentrated animal feeding operations (CAFOs). CAFO rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04). Concentrated Animal Feeding operations fall under Federal regulation and Confined Feeding Operations (CFO) fall under State regulations. Due to this difference CAFO loads fall under WLA and CFO loads fall under LA. CAFOs could be potential sources of nutrients and TSS.

Although there are five active confined feeding operations in Busseron Creek watershed, none are large enough to be classified as CAFOs.

4.1.3 Combined Sewer Systems

Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater into the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a waterbody. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), can contain both storm water and untreated human and industrial waste. Because they are associated with wet weather events, CSOs typically discharge for short periods of time at random intervals.

The Sullivan Municipal WWTP operates the only combined sewer system in the watershed (Figure 6). CSO outfalls 002 and 003 were the only two that discharged for the period September 2007 through March 2008 (the most recent data available) and they are located along Buck Creek on the west side of the city. CSOs can contribute to nutrient and TSS impairments.

4.1.4 Storm Water Phase II Communities

Under Phase II of the NPDES storm water program, rules have been developed to regulate most Municipal Separate Storm Sewer Systems (MS4s). Operators of Phase II-designated small MS4s are required to apply for NPDES permit coverage and to implement storm water discharge management controls (known as “best management practices” (BMPs)). These communities can be potential sources of nutrients and TSS. There are no MS4s within the Busseron Creek watershed.

4.1.5 Illicitly Connected “Straight Pipe” Systems

Some household wastes within Indiana and potentially within the Busseron Creek watershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as nutrients and TSS to the stream (these systems are sometimes referred to as “straight pipe” discharges). These systems are technically classified as point sources; however, since they are illegal, they receive a wasteload allocation of zero.

4.2 Nonpoint Sources

Nonpoint sources include all other categories not classified as point sources. In urban areas, nonpoint sources can include leaking or failing septic systems, runoff from lawn fertilizer applications, pet waste, storm water runoff (outside of MS4 communities), and other sources. In more rural areas, major contributors can be runoff from agricultural lands and abandoned mine lands.

4.2.1 Agriculture

Both cropland and confined feeding operations are potential agricultural sources of impairment in the Busseron Creek watershed.

4.2.1.1 Cropland

Approximately 45 percent of the land in the Busseron Creek watershed is classified as row crops and another 20 percent is classified as pasture and grasslands. These lands can be a source of both sediments and nutrients. Accumulation of nutrients on cropland occurs from decomposition of residual crop material, fertilization with chemical (e.g., anyhdrous ammonia) and manure fertilizers, atmospheric deposition, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities. The majority of nutrient loading from cropland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). Use of manure for nitrogen supplementation often results in excessive phosphorus loads relative to crop requirements (USEPA, 2003).

4.2.1.2 Confined Feeding Operations

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of confined feeding operations falls under the regulations for confined feeding operations (CFOs) and concentrated animal feeding operations (CAFOs). The CFO regulations (327 IAC 16, 327 IAC 15) require that operations “not cause or contribute to an impairment of surface waters of the state”. IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. The rules at 327 IAC 16, which implement the statute regulating confined feeding operations, were effective on March 10, 2002. The rule at 327 IAC 15-15, which regulates concentrated animal feeding operations and complies with most federal CAFO regulations, became effective on March 24, 2004, with two exceptions. 327 IAC 15-15-11 and 327 IAC 15-15-12 became effective on December 28, 2006. CFO and CAFO rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04). The difference between the two feeding operation is that Concentrated Animal Feeding operations fall under Federal regulation and Confined feeding operations fall under State regulations. Due to this difference CAFO loads fall under WLA and CFO loads fall under LA.

The animals raised in confined feeding operations produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. Confined feeding operations, however, can also pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure overapplication can adversely impact soil productivity.

These concerns can potentially contribute to nutrient and TSS impairment in a waterbody. The following five active confined feeding operations exist in the Busseron Creek watershed (Figure 6):

- Bowen Turkey Farm (ID 4939)
- Dear Creek Farm (ID 6008)

- Triple C Farms (ID 6029)
- Long Acre Farms (ID 6142)
- Willis (ID 3994)

4.2.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations in Indiana which contribute to failure are: seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsely and Witten, 1996).

There are a significant number of old houses in the Busseron Creek watershed that either have septic systems that do not function properly or have not been updated to the current standards. Illegal dumping of sewage as well as septic failures are also a common phenomenon in the watershed (Cundiff, 2007), although no information on the specific number of failing systems is available. Failing septic systems are sources of nutrients that can reach nearby streams through both runoff and ground water flows.

4.2.3 Abandoned Surface and Underground Mining

There are approximately 34 square miles of abandoned surface mine sites and 48 square miles of underground mines in the Busseron Creek watershed (Figure 4). The Busseron Creek watershed was extensively coal mined (surface and underground) from the late 1800's until the mid-1900's. Historic practices have had a significant impact on the streams and surrounding landscape of the watershed. Several of these impacts include:

- Residual strip mine ponds and mine waste piles (gob piles)
- Surface hydrology alteration
- Elimination of some headwater streams
- Altered topography and vegetation
- Increased stream bank erosion and sedimentation
- Alteration of fish habitat
- Increased in-stream metals concentrations

The residual effects of historic mining have had a significant influence on water quality as acid mine drainage (AMD) from seeps, mine tailings/gob piles, and exposed coal seems enter into Busseron Creek and its tributaries. AMD generally displays elevated levels of one or more of the following parameters (Bauers et al, 2006):

- Acidity
- Metals
- Sulfates
- Suspended Solids

A number of efforts to address abandoned mine lands in the watershed are already underway, as described in Section 8.1.

It should also be noted that there is an important distinction between abandoned mine lands and current mining practices. Current mines are required to abide by the Surface Mining Control and Reclamation Act of 1977, which addresses the water-quality problems associated with AMD and requires that extensive information about the probable hydrologic consequences of mining and reclamation be included in mining-permit application so that the regulatory authority can determine the probable cumulative impact of mining on the hydrology. Since the onset of the Act, best management practices have been employed at all mine sites and are aimed at minimizing adverse affects to the hydrologic balance. As a result, the current mines in the Busseron Creek watershed are not considered significant sources of the impairments noted in this TMDL.

For purposes of these TMDLs only, point sources are identified as permitted discharge points or discharges having responsible parties, and nonpoint sources are identified as any pollution sources that are not point sources. There is not a single point of discharge associated with abandoned mine lands; therefore, runoff from these areas consists of overland flow. Abandoned mine lands were treated in the allocations as nonpoint sources. As such, the discharges associated with these land uses were assigned LAs (as opposed to WLAs). The decision to assign LAs to abandoned mine lands does not reflect any determination by IDEM as to whether there are unpermitted point source discharges within these land uses. In addition, by approving these TMDLs with mine drainage discharges treated as LAs, IDEM is not determining that these discharges are exempt from NPDES permitting requirements.

5.0 TECHNICAL APPROACH

Previous sections of the report have provided a description of the Busseron Creek watershed, summarized the applicable water quality standards and water quality data, and identified potential sources of the pollutants of concern. This section represents the technical approach used to estimate the current and allowable loads of the pollutants of concern in the Busseron Creek watershed.

Load reductions were determined through the use of load duration curves. The load duration curve calculates the allowable loadings of a pollutant at different flow regimes by multiplying each flow by the TMDL target value and an appropriate conversion factor. The following steps are taken:

1) A flow duration curve for the stream is developed by generating a flow frequency table and plotting the observed flows in order from highest (left portion of curve) to lowest (right portion of curve).

2) The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the TMDL target value and by a conversion factor and the resulting points are graphed. Conversion factors are used to convert the units of the target (e.g., mg/L) to loads (e.g., kg/day) with the following factors used for this TMDL:

   a) Flow (cfs) x TMDL Concentration Target (mg/L) x Conversion Factor (2.45) = Load (kg/day)
   b) Flow (cfs) x TMDL Concentration Target (μg/L) x Conversion Factor (0.00245) = Load (kg/day)

3) To estimate existing loads, each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected and the appropriate conversion factor. Then, the existing individual loads are plotted on the TMDL graph with the curve.

4) Points plotting above the curve represent deviations from the water quality standard and the daily allowable load. Those points plotting below the curve represent compliance with standards and the daily allowable load.

5) The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five "hydrologic zones" (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 10 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to any individual pollutant). For example, the table indicates that impacts from wastewater treatment plants are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their relatively constant loads. In contrast, impacts from channel bank erosion is most pronounced during high flow zones because these are the periods during which stream velocities are high enough to cause erosion to occur. Impacts from abandoned mining areas can occur during all flow zones.

Table 10. Relationship Between Load Duration Curve Zones and Contributing Sources

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Wastewater treatment plants				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflows	H	H	H		
Abandoned Mining	H	H	H	H	H
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)

5.1 Stream Flow Estimates

Daily stream flows are necessary to implement the load duration curve approach. These were estimated using the observed flows available at the USGS gage on Busseron Creek (gage ID 03342500) and drainage area weighting using the following equation:

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} \times Q_{gaged}$$

Where,

$Q_{ungaged}$: Flow at the ungaged location
Q_{gaged}: Flow at surrogate USGS gage station
$A_{ungaged}$: Drainage area of the ungaged location
A_{gaged}: Drainage area of the gaged location

In this procedure, the drainage area of each of the load duration stations was divided by the drainage area (228 square miles) of gage 03342500. The flows for each of the stations were then calculated by multiplying the 03342500 flows by the drainage area ratios. Additional flows were added to certain locations to account for wastewater treatment plants and CSOs that discharge upstream and are not directly accounted for using the drainage area weighting method.

Gage 03342500 was inactive between December 2, 2003 and May 2, 2007, a period which includes the majority of the available water chemistry samples for the Busseron Creek watershed. Flows during this period were therefore estimated based on flows from the nearby Mill Creek watershed as outlined in Appendix G. The Mill Creek watershed was chosen as a “surrogate” gage due to its proximity to the Busseron Creek watershed and its similar hydrologic characteristics. Both watersheds are located in the lower Wabash River watershed; land use in both watersheds is mostly row crops, pasture/grasslands, and deciduous forest (some of the abandoned sites could also potentially be classified as other land uses/land cover); and both watersheds consist primarily of Group C soils. Furthermore, there is a relatively strong correlation between flow data collected concurrently at the two USGS gages (R^2 = 0.74; see Appendix G).

6.0 ALLOCATIONS

This section of the report presents the allowable and existing pollutant loads for the Busseron Creek watershed and allocates the allowable loads as required by the Clean Water Act.

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for unregulated sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

6.1 Approach for Calculating General Permit WLAs

A number of permittees in the Busseron Creek watershed have general rather than individual permits. An individual permit is site-specific and is developed to address discharges from a specific facility. A general permit is used to cover a category of similar discharges, rather than a specific site. IDEM may issue a general permit when there are several sources or activities involved in similar operations that may be adequately regulated with a standard set of conditions.

Calculating WLAs for facilities with individual permits in the Busseron Creek watershed is straightforward; all of the necessary information regarding allowable flows and effluent limits is contained within the permit. Calculating WLAs for facilities with general permits is more difficult because only limited information is available on historical flow and pollutant concentrations. For example, several of the mines in the watershed have general permits for treating runoff; discharge is therefore related to precipitation events rather than a "design" flow as is available for WWTPs. WLAs were therefore calculated by using the drainage area of each permittee to estimate runoff flow volumes and using either existing permit limits or the TMDL targets to calculate the allowable loadings. For example, the size of the Farmersburg Bear Run mine is estimated at 2,427 acres[1] which is 1.6 percent of the 145,920 acres that drain to USGS gage 03342500. Average high flows from the mine were therefore estimated at approximately 16.5 cfs because average high flows at the USGS gage are 1,028 cfs (1.6 % H1,028 cfs = 16.5 cfs). High flow WLAs were thus calculated for this facility by multiplying 16.5 cfs by the following concentrations:

- Total Aluminum: 174 µg/L (TMDL numeric criterion)
- Total Copper: 0.026 mg/L (water quality standard assuming a hardness of 250 mg/L)
- Total Iron: 6 mg/L (general permit limit)
- Total Manganese: 4 mg/L (general permit limit)
- TSS: 70 mg/L (general permit limit)
- Total Zinc: 0.23 mg/L (water quality standard assuming a hardness of 250 mg/L)

The same methodology was used to calculate WLAs for other facilities and flow zones unless noted otherwise in Section 6.2. It should be noted that the current mines in the Busseron Creek watershed are not considered significant sources of the impairments noted in this TMDL.

[1] The Total Performance Acreage Ever Bonded as reported by the IDNR at http://www.in.gov/gis-dnr-web/website/DNR_MineMap_II/viewer.htm was used to estimate the size of the mines in the watershed.

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

6.2 TMDL Results for Each Impaired Segment

The following sections provide the TMDL results for the impaired segments of the Busseron Creek watershed. More details of the load duration curve analysis used to calculate existing and allowable loads are shown in Appendix E.

6.2.1 Sulpher Creek Station 1 (Segment INB11G4_T1004)

Sulpher Creek at Station 1 is impaired due to total aluminum, total iron, total phosphorus, pH and total zinc (Table 11). Historical data indicated that total copper also exceeded water quality standards; however, as recent data do not suggest a total copper impairment, no total copper TMDL was developed.

Table 11. Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1004 (Station 1)

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	9	9	100%	977	14600	9509.70
Total Iron (µg/L)	9	8	88%	2330	32400	7400.00
Total Phosphorus (mg/L)	9	2	20%	0.031	0.503	0.15
pH	8	6	75%	3.79	7.49	5.30
Total Zinc (µg/L)	9	8	88%	45.5	1430	953.17

The TMDL for Sulpher Creek Station 1 is summarized in Table 12. The targets used to develop the TMDL were as follows (see Section 3.2 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Zinc: 239 µg/L

The pH impairment will be addressed by meeting the targets for total aluminum, total iron, and total zinc as explained in Section 3.2.

Abandoned underground and surface mines are located upstream of Station 1 and are considered the primary sources of the metals. As historic abandoned mine lands are considered nonpoint source, any discharge associated with these lands are accounted for in the Load Allocations rather than the Waste Load Allocations. Private sewage systems and agricultural activities are potential sources of phosphorus.

Table 12. TMDL Summary for Sulpher Creek Station 1 (Segment INB11G4_T1004).

Sulpher Creek Station 1 (Segment INB11G4_T1004)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	No Point Sources	133.67	0	23.68	2.63	26.31
	Moist Conditions		69.74	0	5.31	0.59	5.9
	Mid-Range Flows		41.84	0	1.99	0.22	2.21
	Dry Conditions		Unknown	0	0.72	0.08	0.8
	Low Flows		Unknown	0	0.14	0.02	0.16
Total Iron (kg/day)	High Flows	No Point Sources	178.93	0	78.94	8.77	87.71
	Moist Conditions		95.95	0	19.52	2.17	21.69
	Mid-Range Flows		11.99	0	6.62	0.74	7.36
	Dry Conditions		Unknown	0	2.39	0.27	2.66
	Low Flows		Unknown	0	0.49	0.05	0.54
Total Phosphorus (kg/day)	High Flows	No Point Sources	13.96	0	9.48	1.05	10.53
	Moist Conditions		5.66	0	3.04	0.34	3.38
	Mid-Range Flows		0.12	0	0.79	0.09	0.88
	Dry Conditions		Unknown	0	0.29	0.03	0.32
	Low Flows		Unknown	0	0.06	0.01	0.07
Total Zinc (kg/day)	High Flows	No Point Sources	1.6	0	7.54	0.84	8.38
	Moist Conditions		7.59	0	1.69	0.19	1.88
	Mid-Range Flows		4.17	0	0.63	0.07	0.70
	Dry Conditions		Unknown	0	0.22	0.03	0.25
	Low Flows		Unknown	0	0.04	0.01	0.05

Notes: Unknown indicates that no data are available with which to estimate existing loads.

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

Sulpher Creek Station 2 (Segment INB11G4_ T1005)

Sulpher Creek at Station 2 is impaired for total aluminum, total iron, total phosphorus, pH, TSS, and total zinc (Table 13) and the TMDLs are summarized in Table 14.

Table 13. Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1005 (Station 2)

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	9	9	100%	804	13500	6856.73
Total Iron (µg/L)	9	6	66%	943	35900	8106.64
Total Phosphorus (mg/L)	9	4	44%	0.068	1.16	0.35
pH	9	4	44%	4.64	7.52	6.18
TSS (mg/L)	1	1	100%	150	150	150
Total Zinc (µg/L)	9	7	77%	39	1070	593.11

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Suspended Solids: 30 mg/L
- Total Zinc: 178 µg/L

The pH impairment will be addressed by meeting the targets for total aluminum, total iron, and total zinc as explained in Section 3.2.

Abandoned underground and surface mines are located upstream of Station 2 and are considered the primary sources of the metals. Private sewage systems and agricultural activities are potential sources of phosphorus.

Table 14. TMDL Summary for Sulpher Creek Station 2 (Segment INB11G4_T1005).

Sulpher Creek Station 2 (Segment INB11G4_T1005)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	No Point Sources	170.44	0	30.97	3.44	34.41
	Moist Conditions		59.19	0	6.76	0.75	7.51
	Mid-Range Flows		26.92	0	2.60	0.29	2.89
	Dry Conditions		Unknown	0	0.95	0.10	1.05
	Low Flows		Unknown	0	0.19	0.02	0.21
Total Iron (kg/day)	High Flows	No Point Sources	211.50	0	103.23	11.47	114.70
	Moist Conditions		149.23	0	25.69	2.85	28.54
	Mid-Range Flows		4.24	0	8.67	0.96	9.63
	Dry Conditions		Unknown	0	3.13	0.35	3.48
	Low Flows		Unknown	0	0.64	0.07	0.71
Total Phosphorus (kg/day)	High Flows	No Point Sources	20.94	0	12.38	1.38	13.76
	Moist Conditions		8.74	0	3.05	0.34	3.39
	Mid-Range Flows		0.64	0	1.04	0.12	1.16
	Dry Conditions		Unknown	0	0.38	0.04	0.42
	Low Flows		Unknown	0	0.08	0.01	0.09
TSS (kg/day)	High Flows	No Point Sources	Unknown	0	6,895	766	7,661
	Moist Conditions		Unknown	0	752	84	836
	Mid-Range Flows		Unknown	0	144	16	160
	Dry Conditions		Unknown	0	63	7	70
	Low Flows		41	0	7	1	8
Total Zinc (kg/day)	High Flows	No Point Sources	2.05	0	7.34	0.81	8.15
	Moist Conditions		8.25	0	1.72	0.19	1.91
	Mid-Range Flows		4.03	0	0.61	0.07	0.68
	Dry Conditions		Unknown	0	0.23	0.02	0.25
	Low Flows		Unknown	0	0.04	0.01	0.05

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

6.2.2 Sulpher Creek Station 3 (Segment INB11G4_ T1005)

Sulpher Creek at Station 3 is impaired by total aluminum, total copper, total iron, total manganese, total phosphorus, and total zinc (Table 15) and the TMDL is summarized in Table 16.

Table 15. Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1005 (Station 3).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	9	7	77%	136	19700	5103.82
Total Copper (µg/L)	9	1	11%	2.22	43.4	11.77
Total Iron (µg/L)	9	3	33%	476	23600	6831.73
Total Manganese (µg/L)	9	7	77%	374	1560	966.55
Total Phosphorus (mg/L	9	2	22%	0.029	1.04	0.40
Total Zinc (µg/L)	9	5	55%	60.9	632	370.72

The targets and water quality standards used to develop the TMDL were as follows (see Section 3.1 and 3.2 for details):

- Total Aluminum: 174 µg/L
- Total Copper: 11 µg/L
- Total Iron: 2,500 µg/L
- Total Manganese: 514 µg/L
- Total Phosphorus: 0.3 mg/L
- Total Zinc: 102 µg/L

The following three NPDES facilities are located upstream of Station 3:

- Hymera Municipal WWTP (IN0040134)
- Coal Field Development, Hymera Mine (ING040198)

The Hymera Municipal WWTP is not considered a source contributing to the metals impairment (WLAs equal zero), but is a potential source of phosphorus. The total phosphorus WLA allocation was therefore calculated by multiplying the design flow (0.125 MGD) by the TMDL target of 0.3 mg/L.

While not considered a source contributing to the impairment, the Coal Field Development mine is a potential source of total aluminum, total copper, total iron, total manganese and total zinc and currently has a general permit that limits the discharge of TSS, total iron, and total manganese and requires the facility to monitor for total aluminum, total copper, and total zinc. WLAs for the facility were calculated using the approach described in Section 6.1 and an estimated size of the facility of 91.6 acres.

The primary sources of total aluminum, total copper, total iron, total manganese, and total zinc within Sulpher Creek is believed to be abandoned mining areas. The Coal Field Development mine is not considered a source that is contributing to the impairment because:

- The types of impairments observed in at Station 3 exist upstream of the mine, as well as in many other areas of the Busseron Creek watershed.
- The available discharge monitoring report (DMR) data indicate the mine has historically met its permit limits.

Table 16. TMDL Summary for Sulpher Creek Station 3 (Segment INB11G4_T1005).

Sulpher Creek Station 3 (Segment INB11G4_T1005)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	Unknown	1,594.98	0.273	54.375	6.072	60.72
	Moist Conditions	Unknown	29.84	0.08	11.845	1.325	13.25
	Mid-Range Flows	Unknown	1.75	0.024	4.557	0.509	5.09
	Dry Conditions	Unknown	Unknown	0.005	1.651	0.184	1.84
	Low Flows	Unknown	Unknown	0.002	0.34	0.038	0.38
Total Copper (kg/day)	High Flows	Unknown	3.51	0.044	0.784	0.092	0.92
	Moist Conditions	Unknown	0.07	0.014	0.139	0.017	0.17
	Mid-Range Flows	Unknown	0.02	0.004	0.068	0.008	0.08
	Dry Conditions	Unknown	Unknown	0.001	0.026	0.003	0.03
	Low Flows	Unknown	Unknown	0	0.009	0.001	0.01
Total Iron (kg/day)	High Flows	Unknown	1, 910.74	9.425	172.744	20.241	202.41
	Moist Conditions	Unknown	55.22	2.748	43.782	5.17	51.7
	Mid-Range Flows	Unknown	4.58	0.818	14.446	1.696	16.96
	Dry Conditions	Unknown	Unknown	0.182	5.353	0.615	6.15
	Low Flows	Unknown	Unknown	0.068	1.066	0.126	1.26
Total Manganese (kg/day)	High Flows	Unknown	126.30	6.283	22.823	3.234	32.34
	Moist Conditions	Unknown	15.44	1.832	5.683	0.835	8.35
	Mid-Range Flows	Unknown	9.10	0.545	1.894	0.271	2.71
	Dry Conditions	Unknown	Unknown	0.121	0.761	0.098	0.98
	Low Flows	Unknown	Unknown	0.045	0.135	0.02	0.2
Total Phosphorus (kg/day)	High Flows	Unknown	38.54	0.14	21.721	2.429	24.290
	Moist Conditions	Unknown	25.88	0.14	6.880	0.78	7.800
	Mid-Range Flows	Unknown	0.21	0.14	1.687	0.203	2.030
	Dry Conditions	Unknown	Unknown	0.14	0.526	0.074	0.740
	Low Flows	Unknown	Unknown	0.14	0.000	0.016	0.156
Total Zinc (kg/day)	High Flows	Unknown	15.63	0.361	7.091	0.828	8.28
	Moist Conditions	Unknown	9.67	0.105	1.587	0.188	1.88
	Mid-Range Flows	Unknown	3.13	0.031	0.59	0.069	0.69
	Dry Conditions	Unknown	Unknown	0.007	0.218	0.025	0.25
	Low Flows	Unknown	Unknown	0.003	0.042	0.005	0.05

6.2.3 Sulpher Creek Station 4 (Stream Segment INB11G4_ T1006)

Total aluminum is the only parameter of concern at station 4 with all ten of the collected samples exceeding the target value (Table 17). The TMDL summary is presented in Table 18 and the primary source of aluminum is abandoned mining areas. The WLA shown in Table 18 is for the Coal Field Development, Hymera Mine (ING040198).

Table 17. Statistical Summary of TMDL parameters at Stream Segment INB11G4_T1006 (Station 4).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	10	10	100%	195	1800	683.900

Table 18. TMDL Summary for Sulpher Creek Station 4 (Segment INB11G4_T1006).

Sulpher Creek Station 4 (Segment INB11G4_T1006)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	Flow Regime	Point Sources	Nonpoint Sources	WLA: Total	LA	MOS (10%)	TMDL= LA+WLA+ MOS
Total Aluminum (kg/day)	High Flows	Unknown	74.76	0.273	98.098	10.930	109.301
	Moist Conditions	Unknown	10.64	0.080	21.152	2.359	23.591
	Mid-Range Flows	Unknown	14.67	0.024	8.236	0.918	9.178
	Dry Conditions	Unknown	Unknown	0.005	2.983	0.332	3.320
	Low Flows	Unknown	Unknown	0.002	0.609	0.068	0.679

6.2.4 Mud Creek Station 9 (Stream Segment INB11G6_ 03)

Mud Creek at Station 9 is impaired due to total aluminum, total iron, and pH (Table 19). The Indiana Department of Natural Resources (DNR) also samples at this location (station 931A) and the DNR data were therefore incorporated into the analysis (Appendix F).

Table 19. Statistical Summary of TMDL parameters at Stream Segment INB11G6_00 (Station 9.)

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	13	2	15%	26.9	4790	1392.66
Total Iron (µg/L)	20	3	15%	448	4370	1122.06
pH	19	1	5%	5.99	7.70	7.17

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L

The pH impairment will be addressed by meeting the targets for total aluminum, total iron, and total zinc as explained in Section 3.2. The TMDL results are shown in Table 20. There are no point sources located upstream of this station and historic mining areas are believed to be the primary source of total aluminum and total iron.

Table 20. TMDL Summary for Mud Creek Station 9 (Segment INB11G6_03).

Mud Creek Station 9 (Segment INB11G6_03)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	Flow Regime	Point Sources	Nonpoint Sources	WLA: Total	LA	MOS (10%)	TMDL= LA+WLA+ MOS
Total Aluminum (kg/day)	High Flows	No Point Sources	25.31	0	14.62	1.63	16.25
	Moist Conditions		0.59	0	2.00	0.22	2.22
	Mid-Range Flows		0.04	0	0.91	0.10	1.01
	Dry Conditions		Unknown	0	0.33	0.04	0.37
	Low Flows		Unknown	0	0.07	0.01	0.08
Total Iron (kg/day)	High Flows		16.08	0	35.10	3.90	39
	Moist Conditions		16.28	0	8.46	0.94	9.40
	Mid-Range Flows		3.26	0	2.91	0.32	3.23
	Dry Conditions		Unknown	0	1.11	0.12	1.23
	Low Flows		Unknown	0	0.22	0.03	0.25

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

Mud Creek Station 10 (Stream Segment INB11G6_ 03)

Mud Creek Station 10 is impaired due to total aluminum, dissolved oxygen, total iron, and TSS (Table 21). DNR (station 931 B) and USGS (station B10) data are also available for this location and were included in the analysis (Appendix F).

Table 21. Statistical Summary of TMDL parameters at Stream Segment INB11G6_03 (Station 10).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	17	11	64%	56.2	36800	4173.83
Total Iron (µg/L)	20	19	95%	1730	69800	19403.50
TSS (mg/L)	13	7	53%	4	61	36.9083
Dissolved Oxygen	10	1	13%	1.39	12.26	9.28

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L
- Total suspended solids: 30 mg/L

The TMDL is summarized in Table 22. Abandoned mining areas are believed to be the primary source of total aluminum, total iron, and TSS.

The specific cause of the low dissolved oxygen at Mud Creek Station 10 is not known but is believed to be related to the abandoned mine issues. For example, studies have shown that the oxidation of iron can consume a significant volume of dissolved oxygen (USGS, 1986). IDEM has therefore determined that addressing the iron impairment will result in attaining the water quality standards for dissolved oxygen.

AML Site 931 (ING040200) was the only NPDES facility upstream of station 10; this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the Load Allocations rather than the Waste Load Allocations as discussed in section 4.2.3.

Table 22. TMDL Summary for Mud Creek Station 10 (Segment INB11G6_03).

Mud Creek Station 10 (Segment INB11G6_03)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	No Point Sources	219.92	0	68.438	7.604	76.042
	Moist Conditions		47.77	0	13.118	1.458	14.576
	Mid-Range Flows		163.92	0	6.716	0.746	7.462
	Dry Conditions		Unknown	0	2.158	0.240	2.398
	Low Flows		Unknown	0	0.441	0.049	0.490
Total Iron (kg/day)	High Flows		733.39	0	228.126	25.347	253.473
	Moist Conditions		409.64	0	45.995	5.111	51.106
	Mid-Range Flows		225.31	0	21.382	2.376	23.758
	Dry Conditions		Unknown	0	7.192	0.799	7.991
	Low Flows		Unknown	0	1.471	0.163	1.634
TSS (kg/day)	High Flows		3,803.52	0	2633.204	292.578	2925.782
	Moist Condition		1,041.61	0	539.614	59.957	599.571
	Mid-Range Flows		425	0	310.138	34.460	344.598
	Dry Conditions		Unknown	0	86.309	9.590	95.899
	Low Flows		3.67	0	16.495	1.833	18.328

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

Mud Creek Station 11 (Stream Segment INB11G6_ 04).

Mud Creek at Station 11 is impaired due to total aluminum and total iron (Table 23) and the TMDL is summarized in Table 24. The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L

Abandoned (non-reclaimed) mining areas are believed to be the primary source of both pollutants.

Table 23. Statistical Summary of TMDL parameters at Stream Segment INB11G6_04 (Station 11).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	8	4	50%	32.2	10300	2696.87
Total Iron (µg/L)	8	5	62%	116	29300	7131.22

AML Site 931 (ING040200) was the only NPDES facility upstream of this station; this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the Load Allocations rather than the Waste Load Allocations as discussed in section 4.2.3.

Table 24. TMDL Summary for Mud Creek Station 11 (Segment INB11G6_04).

Mud Creek Station 11 (Segment INB11G6_04)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	Flow Regime	Point Sources	Nonpoint Sources	WLA: Total	LA	MOS (10%)	TMDL= LA+WLA+ MOS
Total Aluminum (kg/day)	High Flows	No Point Sources	347.17	0	87.441	9.716	97.157
	Moist Conditions		38.76	0	14.219	1.580	15.799
	Mid-Range Flows		0.35	0	7.296	0.811	8.107
	Dry Conditions		Unknown	0	2.656	0.295	2.951
	Low Flows		Unknown	0	0.543	0.060	0.603
Total Iron (kg/day)	High Flows		558.32	0	291.468	32.385	323.853
	Moist Conditions		471.16	0	65.012	7.224	72.236
	Mid-Range Flows		1.33	0	24.473	2.719	27.192
	Dry Conditions		Unknown	0	8.852	0.984	9.836
	Low Flows		Unknown	0	1.810	0.201	2.011

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

6.2.5 Big Branch Station 12 (Stream Segment INB11G6_ 02)

Big Branch Station 12 was identified as impaired due to total aluminum and total iron based on limited sampling data available from DNR at station 405 C (Table 25). The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total Iron: 2,500 µg/L

A tributary to Big Branch (segment INB11G5_00) was also identified as impaired due to total aluminum and biotic communities. The TMDL is summarized in Table 26.

Table 25. Statistical Summary of TMDL parameters at Stream Segment INB11G6_02 (Station 12).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	2	2	100%	213	868	540
Total Iron (µg/L)	2	2	100%	3590	5500	4550

Abandoned (non-reclaimed) mining areas are believed to be the primary source of both pollutants.

The following four NPDES facilities are located upstream of this station:

- Shakamak State Park (IN0030228)
- Latta Indiana Diesel (IN0002119)
- Farmersburg Mine Bear Run (ING040127)

Shakamak State Park and Latta Indiana Diesel are not considered sources of total aluminum or total iron and the WLAs for these facilities are set to zero. The Farmersburg Mine Bear Run is a potential source of total aluminum and total iron. The WLAs for the Farmersburg Mine Bear Run facility were calculated using the approach described in Section 6.1 using an area of 63 acres. AML Site 931 (ING040200) was upstream of this station; however, this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the Load Allocations rather than the Waste Load Allocations as discussed in section 4.2.3.

Table 26. TMDL Summary for Big Branch Creek Station 12 (Segments INB11G6_02 and INB11G5_00).

Big Branch Station 12 (Segment INB11G6_02)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	Unknown	Unknown	0.364	1530.536	170.100	1,701
	Moist Conditions	Unknown	86	0.106	66.494	7.400	74
	Mid-Range Flows	Unknown	8	0.031	25.169	2.800	28
	Dry Conditions	Unknown	Unknown	0.007	14.393	1.600	16
	Low Flows	Unknown	Unknown	0.002	2.698	0.300	3
Total Iron (kg/day)	High Flows	Unknown	Unknown	12.559	5091.341	567.100	5,671
	Moist Conditions	Unknown	354	3.656	217.744	24.600	246
	Mid-Range Flows	Unknown	207	1.090	83.510	9.400	94
	Dry Conditions	Unknown	Unknown	0.250	46.550	5.200	52
	Low Flows	Unknown	Unknown	0.090	8.910	1.000	10

6.2.6 Kettle Creek Station 13 (Stream Segment INB11G7_ 02)

Kettle Creek at Station 13 is impaired due to total phosphorus and is impaired due to Total Suspended Solids (TSS) (Table 27). The targets used to develop the TMDL are listed below (see Section 3.0 for details) and the TMDL is summarized in Table 28:

- Total Phosphorus: 0.30 mg/L
- TSS: 30 mg/L

There are no NPDES permitted facilities upstream of this station and the primary sources of phosphorus and TSS are believed to be agricultural activities, failing septic systems, and land disturbance associated with historic mining activities.

Table 27. Statistical Summary of TMDL parameters at Stream Segment INB11G7_02 (Station 13).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Phosphorus (mg/L)	9	4	44%	0.134	1.76	0.447
TSS (mg/L)	1	1	100%	296	296	296

Table 28. TMDL Summary for Kettle Creek Station 13 (Segment INB11G7_02).

Kettle Creek Station 13 (Segment INB11G7_02)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	No Point Sources	60.77	0	39.35	4.37	43.72
	Moist Conditions		9.61	0	7.23	0.80	8.03
	Mid-Range Flows		14.52	0	3.30	0.37	3.67
	Dry Conditions		Unknown	0	1.20	0.13	1.33
	Low Flows		Unknown	0	0.24	0.03	0.27
TSS (kg/day)	High Flows		Unknown	0	21,902	2,434	24,336
	Moist Conditions		Unknown	0	2,390	266	2,656
	Mid-Range Flows		Unknown	0	456	51	507
	Dry Conditions		Unknown	0	200	22	222
	Low Flows		250	0	22	3	25

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

6.2.7 Buttermilk Creek Station 16 (Stream Segment INB11G9_ 01).

Based on the available Department of Natural Resources (DNR) data, Buttermilk Creek at Station 16 (319 A) is impaired by total aluminum and TSS (Table 29) and the TMDL is summarized in Table 30. The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Aluminum: 174 µg/L
- Total suspended solids: 30 mg/L

Table 29. Statistical Summary of TMDL parameters at Stream Segment INB11G9_01 (Station 16).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	8	1	12%	180	1020	490.50
TSS (mg/L)	12	2	16%	6	60	19.55

Abandoned (non-reclaimed) mining areas are believed to be the primary source of both pollutants.

There are three NPDES facilities upstream of this station:

- Farmersburg Bear Run (ING040128)
- Dugger Municipal STP (IN0039322)
- Jericho, LLC-Sullivan County CBM Field (IN0062758)

The NPDES permit for Farmersburg Bear Run is inactive; therefore, no WLA is assigned or needed for this facility.

The Dugger Municipal STP has a weekly average TSS limit of 19 mg/L during the summer and 25 mg/L during the winter. These limits were multiplied by the design flow of 0.125 MGD to calculate the WLAs.

WLAs for the Jericho CBM field were calculated using the permitted design flows of 0.303 MGD for high flows and 0.107 MGD for all other flow zones. Jericho CBM Field is not considered a source of total aluminum; therefore, the WLA for total aluminum is set to zero for this facility.

Table 30. TMDL Summary for Buttermilk Creek Station 16 (Segment INB11G9_01).

Buttermilk Creek Station 16 (Segment INB11G9_01)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	0	33.63	0	9.144	1.016	10.16
	Moist Conditions	0	8.04	0	2.25	0.25	2.50
	Mid-Range Flows	0	7.39	0	1.197	0.133	1.33
	Dry Conditions	0	918.81	0	0.432	0.048	0.48
	Low Flows	0	Unknown	0	0.198	0.022	0.22
TSS (kg/day)	High Flows	12	918.81	57.702	1518.954	175.184	1751.84
	Moist Conditions	12	533.21	28.028	226.942	28.33	283.30
	Mid-Range Flows	12	324.35	28.028	178.612	22.96	229.60
	Dry Conditions	9	Unknown	25.189	49.439	8.292	82.92
	Low Flows	9	5.03	25.189	8.426	3.735	37.35

6.2.8 Buttermilk Creek Station 17 (Stream Segment INB11G9_ 03)

Based on the available DNR data, Buttermilk Creek at Station 17 (319 B) is impaired by total aluminum, total iron, and TSS (Table 31) and the TMDL is summarized in Table 32.

Table 31. Statistical Summary of TMDL parameters at Stream Segment INB11G9_03 (Station 17).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Aluminum (µg/L)	10	4	40%	168	2680	705.70
Total Iron (µg/L)	12	9	75%	152	11800	5408.50
TSS (mg/L)	12	2	16%	9	41	22.83

Abandoned (non-reclaimed) mining areas are believed to be the primary source of all three pollutants.

The following three NPDES facilities are located upstream of Station 17:

- Farmersburg Bear Run (ING040128)
- Dugger Municipal STP (IN0039322)
- Jericho, LLC-Sullivan County CBM Field (IN0062758)

The NPDES permit for Farmersburg Bear Run is inactive; therefore, no WLA is assigned or needed for this facility.

WLAs for Dugger Municipal STP, and the Jericho CBM Field were calculated as described in Section 0.

Jericho CBM Field is not considered a source of total aluminum; therefore, the WLA for total aluminum is set to zero for this facility.

AML Site 319 (ING040203) was upstream of this station; however, this facility no longer has an active NPDES permit and any discharge associated with this land area is accounted for in the Load Allocations rather than the Waste Load Allocations as discussed in section 4.2.3.

Table 32. TMDL Summary for Buttermilk Creek Station 17 (Segment INB11G9_03).

Buttermilk Creek 17 (Segment INB11G9_03)		**Existing Daily Loads**		**Total Maximum Daily Load**			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Aluminum (kg/day)	High Flows	0	138.40	0	27.945	3.105	31.05
	Moist Conditions	0	46.62	0	5.319	0.591	5.91
	Mid-Range Flows	0	4.50	0	3.411	0.379	3.79
	Dry Conditions	0	Unknown	0	1.053	0.117	1.17
	Low Flows	0	Unknown	0	0.324	0.036	0.36
Total Iron (kg/day)	High Flows	Unknown	433.22	6.881	394.582	44.607	446.07
	Moist Conditions	Unknown	222.86	2.43	77.679	8.901	89.01
	Mid-Range Flows	Unknown	180.61	2.43	41.967	4.933	49.33
	Dry Conditions	Unknown	Unknown	2.43	12.645	1.675	16.75
	Low Flows	Unknown	Unknown	2.43	2.223	0.517	5.17
TSS (kg/day)	High Flows	12	3897.04	57.702	4759.818	535.28	5352.8
	Moist Condition	12	1107.89	28.028	731.221	84.361	843.61
	Mid-Range Flows	12	639.26	28.028	560.32	65.372	653.72
	Dry Conditions	9	Unknown	25.189	155.666	20.095	200.95
	Low Flows	9	Unknown	25.189	30.674	6.207	62.07

6.2.9 Buck Creek Station 19 (Stream Segment INB11GA_ 03).

Buck Creek at Station 19 is impaired due to dissolved oxygen, TSS, and total phosphorus (Table 33).

Table 33. Statistical Summary of TMDL parameters at Stream Segment INB11GA_03 (Station 19).

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Dissolved Oxygen	7	1	14%	4.79	11.76	9.57
Total Phosphorus (mg/L)	9	5	55%	0.175	0.618	0.32
TSS (mg/L)	1	1	100%	114	114	114

The targets used to develop the TMDL were as follows (see Section 3.1 for details):

- Total Phosphorus: 0.3 mg/L
- Total suspended solids: 30 mg/L

The Sullivan WWTP total phosphorus WLA was established based on the design flow (1.12 MGD) multiplied by the TMDL target value of 0.3 mg/L. This facility already has a permit limit for TSS and this value was used to set the TSS WLAs.

The Sullivan CSO WLAs were based on the TMDL target values of 0.3 mg/L total phosphorus and 30 mg/L TSS multiplied by the average overflow volume event recorded for the period September 2007 through March 2008 (3.96 million gallons). The reported overflow events were assumed to occur during one day and the WLAs were only assigned to the high flow zones.

The cause of the low dissolved oxygen at Station 19 is related to the total phosphorus impairment (i.e., excessive phosphorus is causing the excessive growth of algae which, in turn, are consuming too much oxygen during respiration and when they decay). Addressing the total phosphorus impairment will result in attaining the water quality standards for dissolved oxygen. The TMDL is summarized in Table 34.

Table 34. TMDL Summary for Buck Creek Station 19 (Segment INB11GA_03).

Robbins Creek 19 (Segment INB11GA_00)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	Unknown	84.34	5.80	35.13	4.5	45.43
	Moist Conditions	Unknown	12.82	1.30	8.64	1.10	11.04
	Mid-Range Flows	Unknown	2.97	1.30	2.84	0.46	4.60
	Dry Conditions	Unknown	Unknown	1.30	0.93	0.25	2.48
	Low Flows	Unknown	Unknown	1.30	0.07	0.15	1.52
TSS (kg/day)	High Flows	127	Unknown	577	19,816	2,266	22,659
	Moist Condition	127	Unknown	127	2,156	254	2,537
	Mid-Range Flows	127	Unknown	127	401	59	587
	Dry Conditions	127	Unknown	127	168	33	328
	Low Flows	127	570	127	8	15	150

6.2.10 Robbins Creek Station 20 (Stream Segment INB11GA_ 02).

Robbins Creek at Station 20 is impaired due to total phosphorus (Table 35) and the TMDL is summarized in Table 36. There are no NPDES facilities upstream of this station and sources of total phosphorus are believed to include livestock, agricultural activities and septic systems.

Table 35. Statistical Summary of TMDL parameters at Stream Segment INB11GA_02 (Station 20.)

Parameters	Total Number of Samples	Number of Violations	Percent of Samples Violating Target	Minimum	Maximum	Average
Total Phosphorus (mg/L)	9	2	22%	0.087	0.581	0.23

Table 36. TMDL Summary for Robbins Creek Station 20 (Segment INB11GA_02).

Robbins Creek 20 (Segment INB11GA_02)		Existing Daily Loads		Total Maximum Daily Load			
Pollutant	**Flow Regime**	**Point Sources**	**Nonpoint Sources**	**WLA: Total**	**LA**	**MOS (10%)**	**TMDL= LA+WLA+ MOS**
Total Phosphorus (kg/day)	High Flows	No Point Sources	17.72	0	10.20	1.13	11.33
	Moist Conditions		4.85	0	2.78	0.31	3.09
	Mid-Range Flows		0.31	0	0.85	0.10	0.95
	Dry Conditions		Unknown	0	0.31	0.03	0.34
	Low Flows		Unknown	0	0.06	0.01	0.07

Some impaired segments have WLA of 0. These segments do not currently contain a permitted facility; however, the 0 WLA does not prohibit future permitted facilities from discharging to the segment. The WLA for any new discharger to the impaired segment will be calculated using the WQS or Target for the parameters, as necessary. The TMDL will be modified as needed to account for any allocation changes in the impaired segments.

6.2.11 Busseron Creek Stations 15, 21, and 22 (Stream Segments INB11G8_T1036 and INB11GB_T1037)

Busseron Creek segments INB11G8_T1036 (station 15) and INB11GB_T1037 (stations 21 and 22) are listed as impaired due to poor biotic communities. No pollutants or sources were identified in these segments at this time; therefore, no TMDL or allocations were made for these two segments. These impairments will be addressed by the upstream allocations and reductions. Improved water quality conditions resulting from the TMDLs developed for upstream locations are expected to eventually result in full support of the aquatic life use at segments INB11G8_T1036 and INB11GB_T1037.

6.3 Margin of Safety (MOS)

Section 303(d) of the Clean Water Act and EPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991).

A 10 percent explicit MOS was incorporated into all of the Busseron Creek TMDLs. The use of the load duration curve approach minimizes a great deal of uncertainty associated with the development of TMDLs because the calculation of the loading capacity is simply a function of flow multiplied by the target value. A 10 percent MOS was considered appropriate because the target values used in this study have a firm technical basis as described in Appendix H. A 10 percent MOS was also considered appropriate because the estimated flows are believed to be relatively accurate due to the fact they were estimated based on a USGS located within the watershed (see Section 5.1 and Appendix G for details).

Implicit margins of safety were also used for the metals TMDLs that have criteria that vary by hardness (total copper, total manganese, and total zinc) because the most stringent criteria were used to calculate all of the loading capacities.

6.4 Allocations

6.4.1 Wasteload Allocations

The WLAs developed for this TMDL are summarized in Section 6.2 for each impaired waterbody and are presented individually in Appendix I.

Because the total phosphorus loads from the Sullivan and Hymera Wastewater Treatment Plants had to be estimated, it is recommended that effluent monitoring for total phosphorus be added to these two wastewater treatment plant permits in the next permit renewal cycle. Additional in-stream monitoring should also be performed by IDEM. If the monitoring confirms that the wastewater treatment plant loads are contributing to the impairments, this will need to be addressed by IDEM and the individual facilities after the sampling results are available and interpreted and incorporated into future permits.

Any illicitly connected "straight pipe" systems in the watershed receive a WLA of zero for all pollutants.

6.4.2 Load Allocations

The Load Allocations developed for this TMDL are presented in Section 6.2 and vary for each waterbody and pollutant combination. No information is available with which to distinguish between the natural background sources of the Load Allocations from the sources resulting from anthropogenic activities. Many of the TMDL pollutants (e.g., total aluminum, total copper, total iron, total manganese, total suspended solids, total phosphorus, and total zinc) are found naturally in the soils and ground water of the watershed and thus would be present even in the absence of human activity. Abandoned mine lands were treated in the allocations as nonpoint sources. As such, the discharges associated with these land uses were assigned LAs (as opposed to WLAs).

6.5 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions for the parameters of concern are needed for specific flow conditions; the critical conditions (the periods when the greatest reductions are required) vary by parameter and location and are summarized in Table 37. The table indicates that critical conditions for most pollutants for most locations occur during high flow, precipitation-driven periods and therefore implementation of controls should be targeted for these conditions.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. The load duration approach accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow. Daily flows for the period 1970 to 2007 were used for the load duration analysis and cover the full range of low, average, and high flow periods. Figure 5 indicates that flows are typically the greatest during winter and spring (December through April) and least during late summer and fall (August through October).

Table 37. Critical Conditions for TMDL Parameters

Parameter	Station	Critical Condition				
		High flows	Moist conditions	Mid Range	Dry Conditions	Low Flows
Aluminum, Total (μg/L)	1			X		
	2			X		
	3	X				
	4			X		
	5		X			
	9	X				
	10		X			
	11	X				
	12		X			
	16			X		
	17		X			
Copper, Total (μg/L)	3	X				
Iron, Total (μg/L)	3	X				
	5		X			
	9		X			
	10			X		
	11		X			
	12			X		
	17			X		
Manganese, Total (μg/L)	3	X				
Phosphorus, Total (mg/L)	1		X			
	2		X			
	3		X			
	13			X		
	19	X				
	20					
Total Suspended Solids (mg/L)	2					X*
	10		X			
	13					X*
	16		X			
	17		X			
	19					X*
Zinc, Total (μg/L)	1			X		
	3		X			

Note that limited samples, only available during low flow periods, are available at these locations to calculate observed loads.

7.0 PUBLIC PARTICIPATION

Public participation is an important and required component of the TMDL development process. The following public meetings have been held in the watershed to discuss this project:

- A **Kickoff Meeting** was held at the Sullivan County Public Library on March 14, 2007 during which IDEM and Tetra Tech described the TMDL Program and provided a summary of the available data and the proposed modeling approach.
- A **Draft TMDL Meeting** was held at the Sullivan County 4-H Fairgrounds Meeting Room on January 31, 2008 during which IDEM and Tetra Tech described the TMDL Program and provided an overview of the draft TMDL results.
- An **Initial Comment Period** began January 23, 2008 and ended March 5, 2008.

The second comment period for the revised draft TMDL will be held from June 16, 2008 to July 16, 2008.

8.0 IMPLEMENTATION

A variety of controls will need to be implemented to address the sources of impairment in the Busseron Creek watershed. A brief summary of the issues and progress already made for some of the most significant sources is provided below. More specific goals and activities should be identified by persons concerned with improving the health of the watershed. IDEM has Watershed Specialists assigned to different areas of the state and these Watershed Specialists are available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the watershed.

8.1 Abandoned Mine Lands

DNR has a number of watershed projects ongoing throughout the Busseron Creek watershed, primarily to address the issues with abandoned mines. For example, as shown in Table 38 approximately 32,200 tons of lime have been applied to six different sites to neutralize acidic runoff and almost 500 acres of land has been reclaimed by addressing gob piles, slurry spoils, and unvegetated areas (Mark Stacy, DNR, personal communication dated June 15, 2007). Several wetland treatment projects have also been installed to treat acid mine drainage.

Table 38. Summary of DNR mine reclamation projects within the Busseron Creek watershed.

Site	Name	Construction Dates	Amount ($)	Tons of Lime Applied	Total Acres Reclaimed
317	Big Branch	3/9/01 - 4/10/01	254,348.91	1400	22.5
318	Peabody 48	4/7/03 - 8/22/03	76,652.32	200	6.5
319	Vandalia	9/7/04 - 10/12/05	1,441,984.81	2900	102
322	Pandora	10/16/89 - 7/2/90	165,250.93	500	22.5
931	Big Bertha	7/22/04 - 5/24/05	609,051.19	2200	32
287	Friar Tuck	3/30/89 - 5/9/05	1,758,688.49	25,000	295.7

8.2 Agriculture

Nonpoint source pollution from agricultural areas can be reduced by the implementation of best management practices (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, changing a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Landowners can implement BMPs outside of a watershed management plan, but the success of BMPs is typically enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be appropriate for the Busseron Creek watershed:

8.2.1 Vegetated Filter Strips

Vegetated filter strips are used to reduce the amount of nutrients and sediments that enter a waterbody, reduce erosion around a stream channel, and protect a waterbody from encroachment. Targeted placement of vegetated filter strips can play an important role in reducing pollutants in the watershed.

If vegetated buffers are designed correctly, they can prevent suspended solids, nitrogen, and phosphorus from entering a stream. The ability of the buffer to uptake phosphorus depends on the filter strip design, residence time of the water, and slope of the land. Suspended solids (which can transport phosphorus) are more easily removed by vegetated buffers through settling.

Pennsylvania State University (1992) estimates that the preferred filter strip width for phosphorus will remove 50–75 percent of total phosphorus. Local NRCS personnel and soil and water conservation districts should be consulted to determine the most appropriate design criteria and placement of filter strips in the Busseron Creek watershed.

8.2.2 Nutrient Management Plans

Nutrient management plans are often implemented to help maximize crop yields while using nutrient resources in the most efficient, environmentally sound manner. The plans help guide landowners by analyzing agricultural practices and suggesting appropriate nutrient reduction techniques. This is often done by managing the amount and timing of nutrient fertilizers on agricultural land in the watershed. Nutrient management plans are tailored for specific fields and crops. Because of this, they require site specific sampling and planning. USEPA (1993) suggests that the nutrient management plan include:

- Maps and data regarding the farm size and type of crops grown
- Realistic yield expectations based on soils and past crop yields
- Summary of the nutrient resources available
- An evaluation of field limitations and hazards
- Use of the limiting nutrient concept to apply nutrients based on realistic crop expectations
- Specific timing and application data for nutrients
- Provisions for proper calibration and operation of nutrient application equipment
- Annual reviews and monitoring

Using these plans, a landowner can apply fertilizers based on the limiting nutrient in the soils and realistic crop yields.

Limited information is available on the effectiveness of nutrient management plans to reduce loads of phosphorus. The effectiveness will vary a great deal depending on the application rate prior to implementation of the plan and site-specific factors such as crop types and soil characteristics.

Landowners/operators should contact their local soil and water conservation district to obtain information about obtaining funding.

8.3 Septic Systems

Septic systems provide an economically feasible way of disposing of household wastes where other means of waste treatment are unavailable (e.g., public or private treatment facilities). However, failing septic systems can contribute to excessive nitrogen, bacteria, and phosphorus loads, the latter of which is a TMDL pollutant in the Busseron Creek watershed.

Septic system failure occurs when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. The waste may pond in the leach field and ultimately run off into nearby streams or percolate into the groundwater system. The most common reason for failure is improper maintenance. Other reasons include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste.

Many homeowners do not realize they have a failing septic system. One recommendation is to initiate an outreach program to educate residents about septic systems. The components of an example outreach program are illustrated below:

- Make homeowners aware of the age, location, type, capacity, and condition of their septic system.
- Teach homeowners to recognize a failing septic system.
- Teach homeowners about proper septic system maintenance.
- Provide information about different types of septic systems, and their costs, advantages, and disadvantages.
- Provide consultation and inspection services to homeowners.
- Teach homeowners about water quality concerns in their watershed.

In addition to conducting a public outreach campaign, an effort should be made to identify and repair failing systems. In some cases systems might need to be replaced. Systems located in close proximity to streams impaired by nutrients should be targeted first. This effort should be coordinated by the appropriate county health department.

Finally, an effort needs to be made to ensure that septic systems are properly maintained. Homeowners should pump out or inspect their septic tanks on a regular schedule. Septic tanks should be pumped when the solids in the tank accumulate to a point where the effluent no longer has enough time to settle and clarify. The timing of the pump-out depends on the tank and household size.

8.4 Monitoring Plan

Future monitoring of the Busseron Creek watershed will take place during IDEM's five-year rotating basin schedule and/or once TMDL implementation methods are in place. Monitoring will be adjusted as needed to assist in continued source identification and elimination. IDEM will monitor at an appropriate frequency to determine if Indiana's water quality standards are being met. When these results indicate that the waterbody is meeting the water quality standards, the waterbody will then be removed from the 303(d) list.

8.5 Watershed Projects

The Sullivan County SWCD is producing a watershed management plan (WMP), funded in 2007, for the Busseron Creek watershed, Hydrologic Unit Code (HUC) 05120111160. A steering committee of local stakeholders will be formed to guide the development of the WMP. A monitoring program will be built based on the TMDL sampling and constructed to investigate water quality concerns in the watershed. The district will also implement an outreach program to educate the public about the project and encourage behavior change and better environmental decisions. The program will include field days or workshops, newsletters, educational material about watershed management to schools, civic groups and other organizations, and information to the local media. When the WMP is complete, the District will implement a cost-share program to install best management practices in critical areas in the watershed as identified in the plan.

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